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PRODUCT ENGINEERING

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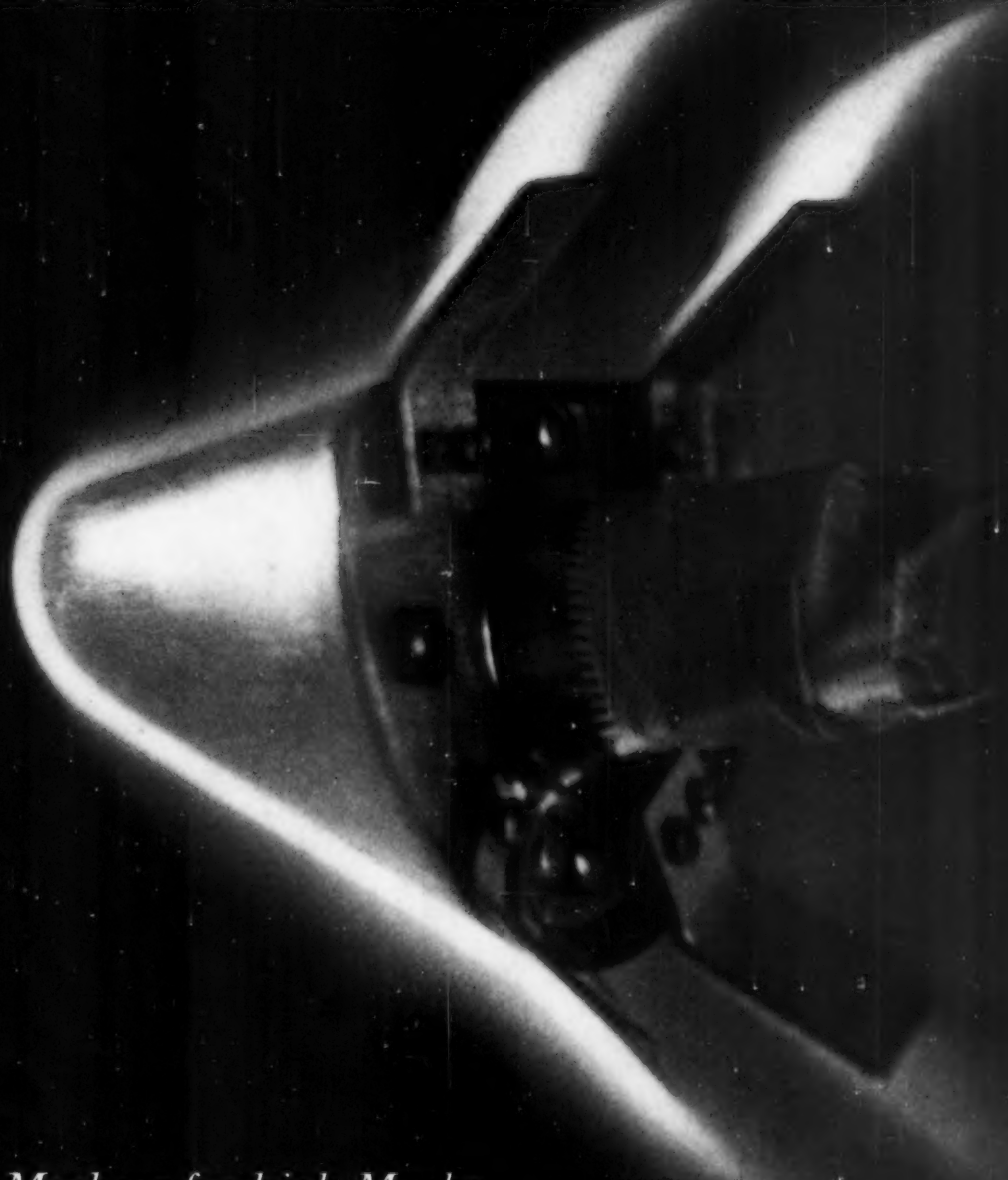
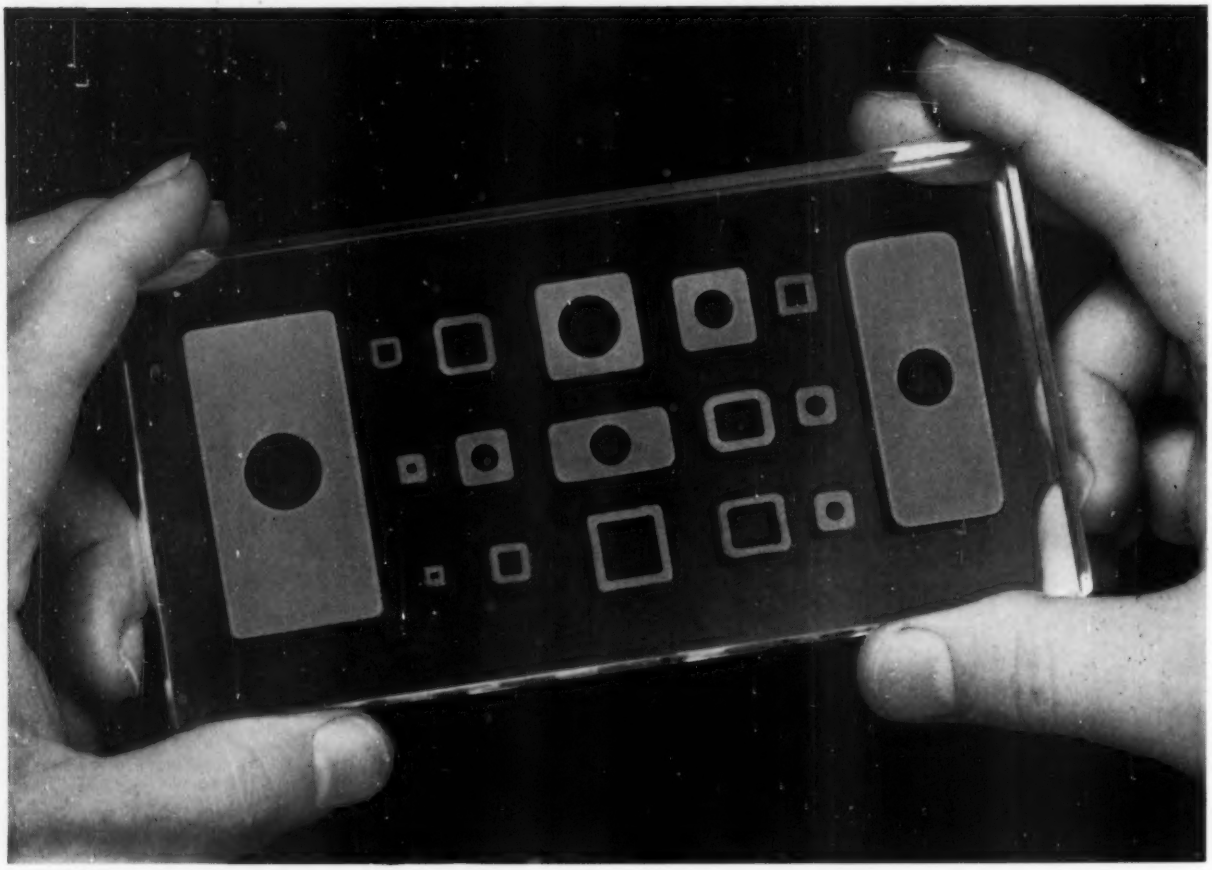


Mock-up for high Machs . . . *see page 3*

a new look at hollow conductors



Cross sections of some typical hollow copper conductors produced by Anaconda American Brass Company

Anaconda makes conductors to meet new needs in fluid cooling of windings, bus, and heat sinks

The high electrical and thermal conductivities of copper —the highest among commercial metals—are being utilized in fluid-cooled conductors to do a host of new jobs.

Fluid-cooled copper conductors are making possible more compact electrical assemblies to handle high current densities and uses are growing rapidly in large electrical equipment. Generator output, for example, can be greatly increased, without increasing frame size, by cooling the stator bars.

In such applications as heat sinks for power rectifiers and induction furnace coils—where controlled heat dissipation is essential—the use of fluid-cooled copper conductors is a natural.

Water-cooled windings produce the very high flux densities needed in the compact equipment for the ceramic magnet manufacturing process. The current range in these "solenoids" is from a few hundred to about 2000 amperes.

Of course, the most spectacular applications of fluid-cooled conductors are in nuclear physics magnets. These hollow conductors range from tube .182″ square O.D. x .083 square I.D. to heavy rectangular bars with a round core for water cooling.

TECHNICAL ASSISTANCE. The cross sections of hollow conductors shown above indicate but a few of the many ways in which Anaconda American Brass is shaping copper to meet these new needs. Whatever your requirement, Anaconda specialists will gladly help you work out the size and shape best adapted to your needs. For such assistance, see your Anaconda American Brass representative, or write: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

February 27, 1961 Vol. 32, No. 9

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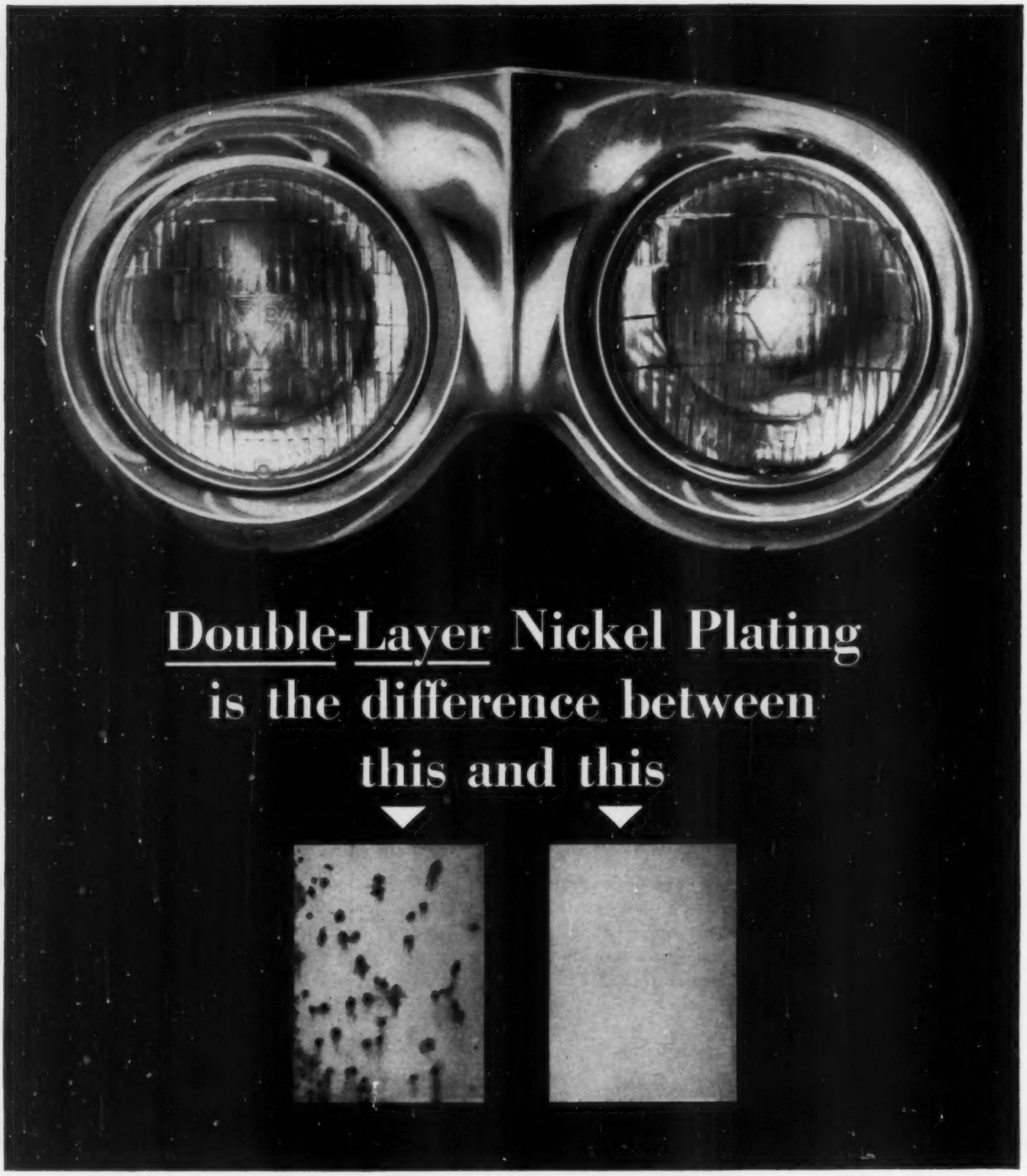

Double-Layer Nickel Plating is the difference between this and this

Both of these plated panels were exposed in a corrosive marine atmosphere for 18 months!

You can see how the panel on the left — plated with a Nickel-Chromium coating that is perfectly suitable for less rugged use — fared in this severe outdoor test.

But the panel on the right — *coated to the same 2.0 mil thickness* — retained its rich original luster!

Why? *Double-Layer* Nickel Plating — a good thick layer of sulfur-free, semi-bright Nickel beneath the lustrous bright Nickel layer and the thin chromium overlay.

Remarkably durable, this combination provides outstanding resistance to corrosion, abrasion and wear . . . helps assure the mirror-bright, *lasting* eye appeal that satisfies today's quality-conscious customers.

For more information on the durability of decorative Nickel-Chromium plating, write for your free copy of "*The Contribution of Nickel and of Chromium to the Durability of Decorative Plating.*"

The International Nickel Company, Inc.
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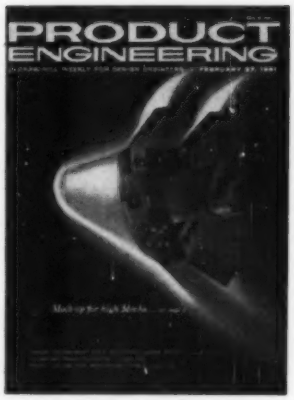
INTERESTING TO NOTE



On our cover—configurations for reentry vehicles are vital because they determine heating rates. So Ames Research Center, NASA, Moffett Field, Calif, has been doing a great deal of testing in its 1-ft hyper-velocity shock tunnel (photo, right), built in 1958. This is one of half a dozen, at most, in the country, and is a combination of wind tunnel and shock tube. Oxygen and hydrogen, with helium, are mixed in the chamber at the far end—really a section of 16-in. naval rifle—and ignited by annular electric heating wires. The resulting combustion pressure ruptures a diaphragm, compacts an air column and forces it through an extremely small-throat venturi (diameter may be $\frac{1}{8}$ in. or less) into a 1 x 1-ft test chamber and on into a collector tank. Expansion through the venturi produces Mach 9.5 for 120 milliseconds, resulting in stagnation temperatures at the model as high as 8000 F.

Reentry-configuration models, like that on our cover, are placed in this airstream to obtain basic data on heat transfer at high temperatures and to compare these with similar tests at low temperatures. Tests are photographed in color, but with very short (1 or 2 millisec) exposures, through a quartz window. Unlike a normal instantaneous photo, however, our cover shot shows a full cycle of test. In this model, the flat top gives lift to reduce the angle of reentry. The flaps represent elevators (top) and rudders (bottom).

To produce nosecone models at a rate of two a day, and within two or three days from conception, Albert Clarke worked out an interesting combination of thermoforming and investment casting (see story, page 42).

His Sticky Valve Struck Oil

There is nothing more aggravating than trying to open a valve that appears immovable—unless it's when the valve snaps, leaving you with a messy leak. In 1914, a Swede named Sven Nordstrom was faced with a similar problem. He was an engineer engaged in the construction of a filtering plant for the LaBlanca Mill in Pachuco, Mexico. The mill had four tanks that agitated a cyanide solution used in processing silver. Since it was most important to have positive-shutoff valves on all the highly caustic cyanide lines, Nordstrom used English-made stopcocks, which were the best available at the time.

But when these valves didn't stick, they leaked. After several battles with some frozen stopcocks, Nordstrom decided that there must be a better way to open a valve.

continued, next page

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He first tried drilling a hole beneath the valve seat, inserting a screw and, by applying pressure on the plug, unseating it and opening the valve. It soon became obvious that this method would be too cumbersome.

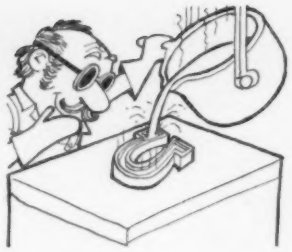
Nordstrom next decided to apply Pascal's Law and lift the plug hydraulically. If a lubricant were inserted under the plug and compressed by turning a screw it would unseat the plug if the pressure were great enough. As his first lubricant, Nordstrom used a Mexican tallow candle which was being used for lighting the mine shafts. The lubricated valve was successful, but it took another year before Nordstrom had his valve ready for marketing. He received his patent in 1916, immediately commenced manufacture, and made a nice thing for himself out of the discovery.

Nordstrom's valves solved many problems of the day. Now, valves are called upon to solve a multitude of assorted new problems. When fluid flow must be varied in unusual ways, for example, valves for nonlinear flow must be designed. The article on page 48 gives some pointers.

Milestone in Steel

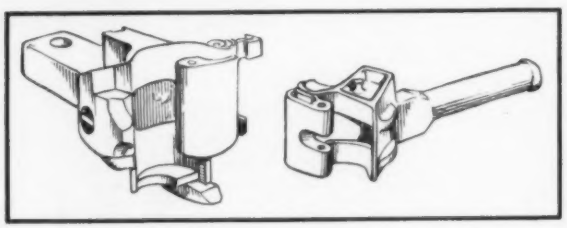
This year, aside from marking the Centennial of the Civil War, is also the 100th anniversary of America's steel-casting industry. According to Wilson H. Moriarty, president, Steel Founders' Society of America, "it was in Buffalo in 1861 that a small company known as Buffalo Iron Works poured the first crucible-steel castings in the United States. Those early castings were poured for our first and still largest customer—the railroads."

A method of casting steel to final shape was first reported in 1845 when Swiss metallurgist Johann Fisher applied for a British patent to cover "a new way to make horseshoes." His cast horseshoe found a market in Europe and America. (In fact, a foundry in Iowa still produces cast-steel horseshoes.) It was not until 1871, however, that the first company devoted exclusively to the manufacture of steel castings was organized—The Pittsburgh Steel Castings Co. It produced cast plowshares and other implements for the agricultural-machine industry.



Relatively few castings were poured in the early days simply because of the physical effort needed to charge the open hearths. It took four or five men about four hard hours to charge a 15-ton furnace. A machine will charge a 50-ton furnace today in less than an hour.

The industry received a boost in the early 1870s. The invention of the air brake by George Westinghouse and the railroad-car coupler by Eli Janney made possible trains



of such length that material for Janney's automatic couplers was changed from malleable iron to cast steel. Casting methods have since taken tremendous strides. As the article on page 42 points out, a new casting technique can produce metal and plastic parts with walls down to 0.010 in.

—Benedict A Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

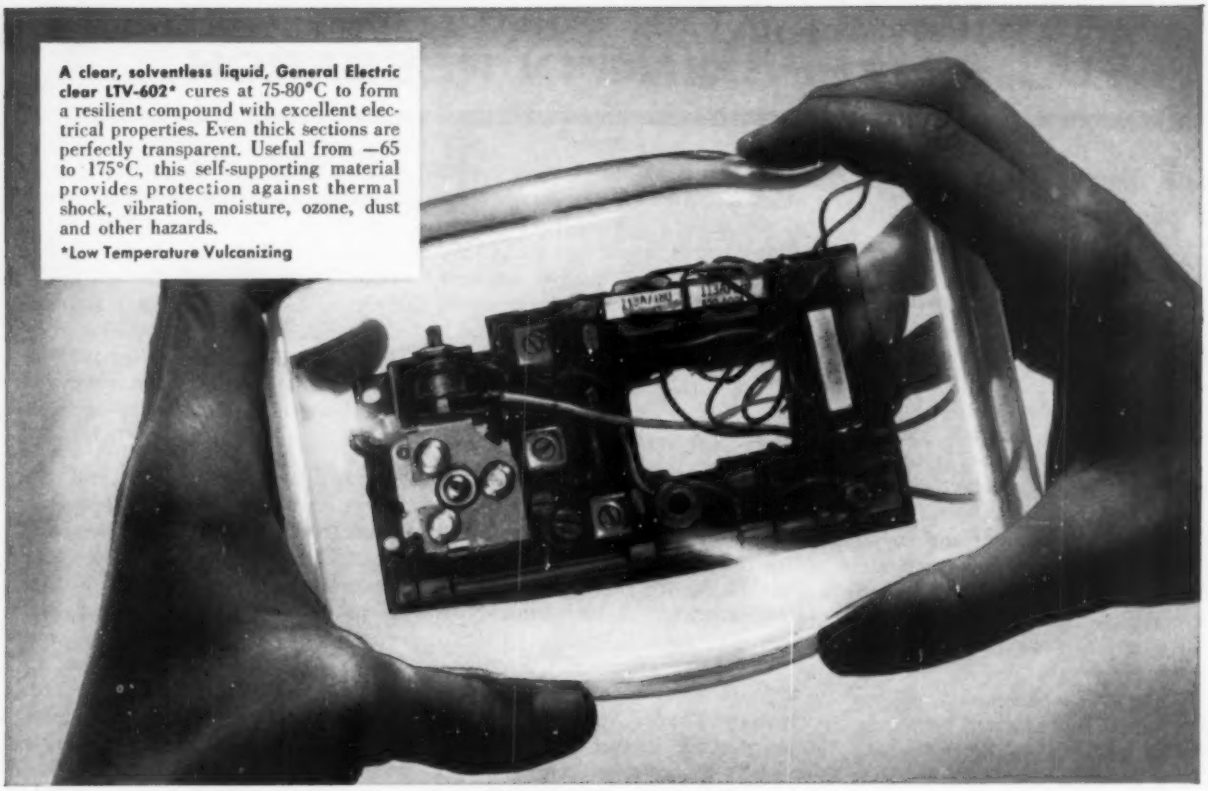
. . . **How Practical Is 400-cycle Power Today?**
This high-frequency power does many jobs better than standard 60-cycle variety. And compact static frequency-converters will soon be cheap enough to handle many jobs, old as well as new.

. . . **When Linkages Need Harmonic Analysis**
Now, with this handy table, you'll find it easier to perform the analysis needed for efficient crank-and-rocker mechanisms.

. . . **Choosing the Right Soft Solder Alloy**
Author discusses the solders themselves—comparing the 30 basic types and showing how to select them for your design problem.

. . . **The Acceleration of Science—Crisis in Our Technological Civilization**
A noted science historian presents some startling figures on the exponential growth of science today.

. . . **Eight Paper-feed Mechanisms**
In a world of reports, forms and memos, a prime need is to keep paper moving. Here are some ways that do the job for single sheets or continuous strip.

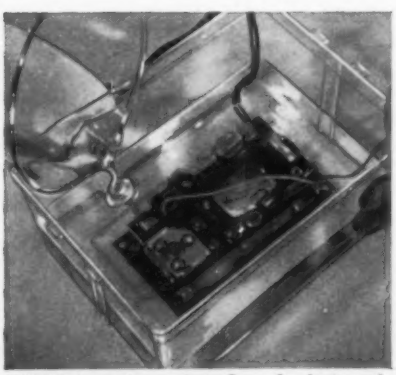


A clear, solventless liquid, General Electric clear LTV-602* cures at 75-80°C to form a resilient compound with excellent electrical properties. Even thick sections are perfectly transparent. Useful from —65 to 175°C, this self-supporting material provides protection against thermal shock, vibration, moisture, ozone, dust and other hazards.

*Low Temperature Vulcanizing

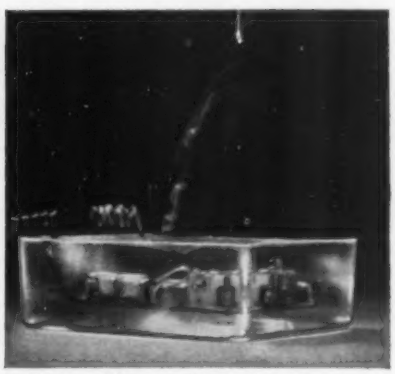
General Electric clear LTV silicone compound for potting and embedding

Transparent, resilient, self-supporting and easy to repair



LTV-602 is easily applied, flows freely in-and-around complicated parts. Having a low viscosity in the uncured state, 800-1500 centipoise, LTV is ideal for potting and embedding of electronic assemblies. Unlike "gel-like" potting materials, LTV-602 cures to a flexible solid. Oven cure is overnight, or from 6 to 8 hours at 75 to 80°C.

LTV-602 is easy to work with and easy to repair. To repair parts embedded in LTV, merely cut out and remove section of material, repair or replace defective part, pour fresh LTV into opening and cure. Pot life, with catalyst added, is approximately 8 hours and may be extended with refrigeration. When desirable, LTV may also be cured at room temperature.



Resiliency offers excellent shock resistance. LTV-602 easily meets thermal shock tests described in MIL-STD-202A test condition B which specifies five temperature cycles from —65 to 125°C. Tests indicate that LTV retains protective properties even after 1800 hours aging at 175°C. Other tests confirm LTV's resistance to moisture and water immersion.

LTV-602 is the newest addition to the broad line of G-E silicone potting and encapsulating materials which also include the RTV silicone rubbers. For more information, write to General Electric Company, Silicone Products Department, Section A240, Waterford, New York.

GENERAL ELECTRIC

WHAT'S HAPPENING IN RESEARCH...

New films to conduct electricity

Transparent, electrically conductive films that use cadmium oxide as the base in place of the more conventional tin compounds are being developed by Sir Thomas Merton, fellow of Britain's Royal Society.

The process involves dipping the part to be coated (generally glass) in a cadmium salt–organic solvent mixture (ethyl alcohol–acetone–cellulose nitrate) and heating to about 800 F to evaporate the solvent and deposit a cadmium-containing collodion film. Further heating then oxidizes the cadmium salt and vaporizes the collodion, leaving a transparent, adherent electrically conductive film.

With the process, says Merton, large areas can be coated simply and cheaply, and the coating can serve as a base for deposition of other metal layers for higher conductivity if desired.

Information on the process may be obtained from National Research Development Corp, Suite 503, Mercury Building, Washington 6, DC.

Accelerator costs are on the rise

High-energy particle accelerators are getting more numerous and more useful; but their cost is going up too. The present price tag is $1 to $3 million per billion electron volts. A survey of US machines by the European Organization for Nuclear Research shows that, of those now in operation, the 1.2-bev unit at Cal Tech (completed in 1953) was the "cheapest"—just a little over $1 million/bev.

The 25 to 30-bev machine that went into operation at Brookhaven this year was relatively cheap too: $31 million: But the Princeton-Pennsylvania 3-bev proton accelerator, scheduled for completion next year, will cost $11.2 million—more than $3 million per bev; and Argonne's 12½-bev accelerator, to be finished in 1962, will cost $29 million—or more than $2 million/bev.

Now, MURA (Midwest Universities Research Assn) is estimating that a "clashing beam" proton accelerator, which would extend the energy range by producing a collision between two particle beams, would cost about $200 million. Although such a machine would be rated at 15 bev, it would produce the energy equivalent of a 540-bev unit.

New electron lens promises higher order of resolution

An electron microscope lens with an annular objective is under test at Oak Ridge National Laboratory. The aim: to remove the aperture limitations inherent in conventional designs.

As T. A. Welton and J. Kronsbein of U of Florida pointed out to an American Physical Society symposium, the objective lens of a conventional electron microscope consists of a static, axially symmetric magnetic field with electrons confined to trajectories near the axis. For such a lens, they say, "the lowest order spherical aberration which is in principle possible is actually of definite sign. This essential spherical aberration operates in practice to make the minimum resolvable distance considerably greater than a typical atomic spacing by restricting the numerical aperture to values between 0.01 and 0.001."

It is this limitation which, it is hoped, the new design will overcome.

briefs . . .

Negative photoconduction is one of several unusual effects observed in zinc-doped germanium at low temperatures, R. J. Keyes of Lincoln Laboratories reported to The American Physical Society. And, he says electrical effects in this semiconducting material are of a considerably higher order than any previously reported. That means it could open the way to new low-temperature devices utilizing its special sensitivities.

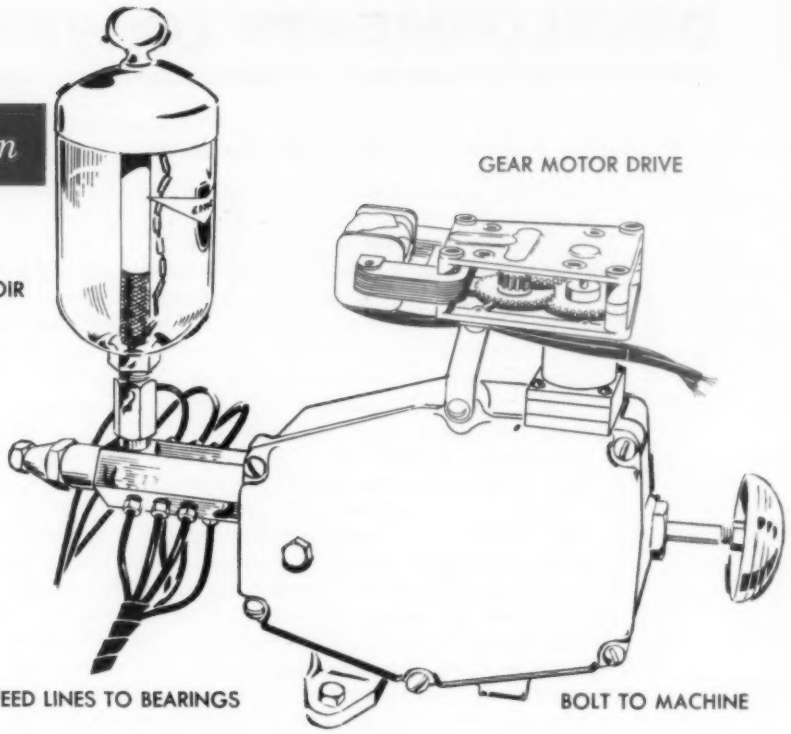
New studies of liquid metals and molten salts as heat-transfer media (*PE—Oct 24 '60, p 45*) are reported by Naval Research Lab's Chemistry and Metallurgy divisions. Measurements have been made of thermal conductivity and corrosivity, and three reports on these studies (NRL 5555, 5568 and 5572) are now in preparation. To be released through OTS, Dept of Commerce, Washington 25 DC., the reports cover solubility in liquid-metal systems, radiant-heat transfer and thermal conductivity of fluoride salts, and corrosivity of alkali metals.

Masers, lasers, and irasers will get major attention from commercial producers as well as researchers this year. These amplification devices—for microwaves, visible light, and infrared—are opening brand-new approaches to electronic equipment design, and they've moved from basic science to application lab with amazing speed. The oldest of the three devices, the maser (*PE—Jan 13 '58, p 10*) is barely out of its swaddling clothes; and the others were announced only last year (*PE—July 25 '60, p 20*). Yet companies like Electro-Optical Systems are already establishing new divisions to produce and sell them. The name of the new E-OS unit is itself an indication of the speed with which "advanced" science is moving into industry. It's the Quantum Electronics Div, and it's set up as a commercial, not a research unit. (Note: for information on the latest development, a continuously operating optical maser, see (*PE—Feb 13, p 18*).

—ARG

TRITIUM LIGHTS UP watch dial in one of its first commercial applications, heralding release of this man-made radioactive isotope for nonnuclear use (**PE—Dec 16 '57, p 5**). Vial of tritium (left) is supplied by New England Nuclear; dial is marketed by Luminous Products Corp.

Design tips from Lincoln



Simple Gear Motor on Ratchet Multi-Luber® makes Automatic Electric Lubrication System

You can use a simple gear motor to drive Lincoln's new ratchet Multi-Luber to get a simple, low-cost electric lubrication system for light machinery of all types. Gear motor ratios of 1, 2, or 3 rpm and ratchet Multi-Luber ratios of 25:1, 50:1 and 100:1 let you choose the lubrication interval best suited for the machine.

The gear motor can be wired to any 110V/AC circuit so that the Multi-Luber provides lubrication whenever the machine is running. With standard setting, the Multi-Luber discharges 0.0025 ounces of lubricant (grease or oil) from each of the 12 outlet ports every time it cycles. Output of the first four ports can be doubled. The gear motor installs easily . . . you need only a clutch plate for the $\frac{3}{16}$" output shaft and a mounting bracket.

You can use the gear motor if rotating or reciprocating motion is not available to drive the ratchet arm or if remote location of the lube unit is desirable to protect it during steam or caustic cleaning.

Multi-Luber units on cottage cheese packaging machines are giving these advantages according to the manufacturer: protect bearings against water contamination during steam cleaning, eliminate product contamination by lubricant, eliminate removal of protective side panels to manually lubricate, provide constant film lubrication on bearings. They have also extended the manufacturer's field service check from 90 to 120 days.

Note to Manufacturers:
Lincoln assists manufacturers in adapting automatic lubrication system to machinery . . . contact Lincoln's Original Equipment Sales Division.

LINCOLN ENGINEERING COMPANY
Original Equipment Sales Division
4010 Goodfellow Blvd., Dept. PE-1
St. Louis 20, Mo.

☐ Please send operating data sheet and Catalog 50 on Multi-Luber.
☐ Have your representative call to advise me on Multi-Luber adaptation to my machines.

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DEVELOPMENTS TO WATCH...

Flexible insulation heads for ultrahigh temperatures

New wire-and-coating combinations that promise excellent performance at temperatures at least to 1000 F are reported by Raytheon Co as part of a major study of insulated conductors for ultrahigh-temperature service.

Several types of conductors are now available for this purpose, but each has rather severe limitations. For instance, glass-served wire has an undesirable space factor. Ceramic-coated nickel-clad wire loses conductivity through diffusion of nickel into the copper during service. Anodized aluminum, too, has a relatively low conductivity factor and lacks mechanical strength at high temperature.

To get around these problems, Raytheon has been testing a number of new combinations, among them, anodized tantalum and columbium coatings on copper and silver. J. F. Ahearn of Raytheon's Transformer Div says they have excellent flexibility and high dielectric strength, but need protection from oxidation at temperatures above 600 F.

High-purity chrome plate on silver or copper looks much better. Chrome-plated wire, Ahearn says, is free from diffusion effects and retains its high conductivity for at least 2000 hr at 1000 F and above. In the 1000-F range, though, it does require an inert-gas atmosphere. Ceramic coating of the oxidized chromium surface may be one way to get around this problem. Such coatings are now under test at Raytheon and, Ahearn says, show high conductivity and an excellent space factor. Abrasion resistance must, however, be improved.

Other approaches, now being considered, include micronized aluminum oxide on copper, and electrophoretically deposited inorganic-fiber particles to provide the advantages of glass-wound wire without its space penalties.

Molten metal may drive subs

Liquid lithium, reacting with water, may serve as fuel for submarines of the future.

Using lithium as "fuel" and sea water as the "oxidant," the Naval Ordnance Pasadena test station has built a combustion chamber which operated for about 3 min. at about 95% efficiency.

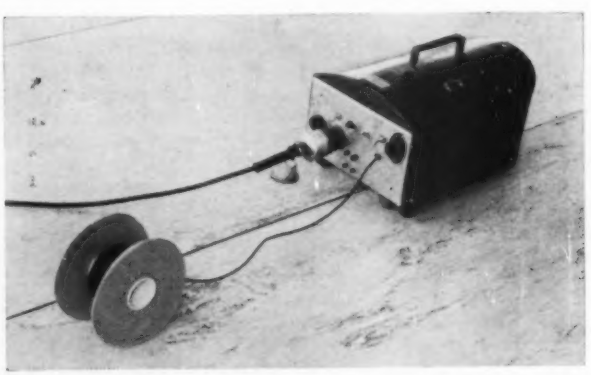
Hooked up to a gas turbine which converts 50% of the heat energy into mechanical energy at a 20-to-1 pressure ratio, the device would show a specific fuel consumption on the order of 1.5 lb/shaft hp-hr.

The system has many obvious disadvantages, the Navy admits, not the least of which is the problem of handling a reactive metal which must be heated to a melting point of about 370 F. But, the Navy says, "These troublesome aspects can probably be tolerated, and the use of molten lithium as a water-reactive fuel can result in a superior propulsion system."

British develop automatic welder for plastics

A portable welding head that feeds a plastic filler rod has been developed by Phoenix Rubber Co, of Buckinghamshire, England.

Essentially, it's a multistage blower delivering air at high speed to a vertical heating chamber. Here, the air is heated to 500 F and fed against the filler rod, which itself is guided by a grooved wheel that lays it neatly in the joint being welded. A fractional-hp geared motor drives the unit at 2 to 4 ft/min. The unit also has a chisel to remove excess filler after deposition. A unit specifically designed for plastic flooring weighs 36 lb, is 19 by 11 by 12 in.



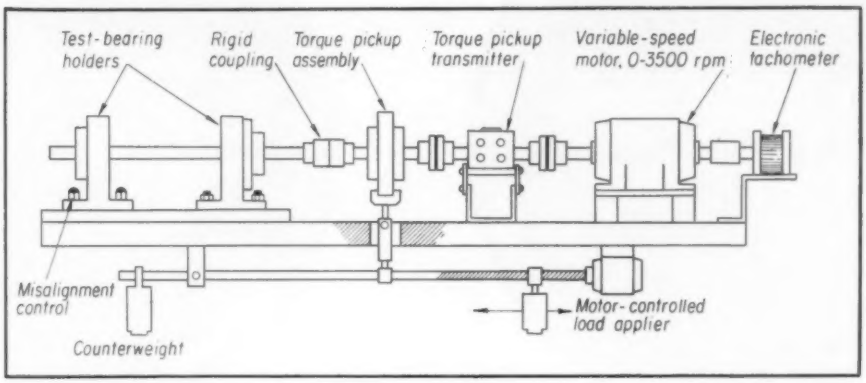
AUTOMATIC WELDER for sheet plastics has pushbutton controls mounted on back panel. Filler rod feeds through machine from back to front as the welder rolls along.

Electronic instrument gives continuous record of bearing performance

An electronic analyzer that will provide a continuous record of bearing speed and friction loses is in advanced stages of development at Tann Corp, Detroit. It will monitor bearing temperature, measure torque lost to the bearing, and plot coefficient-of-friction curves.

The diagram shows basic components of the machine as it now stands. When in final form, it is expected also to be able to measure shaft deflection, variations in oil-film configuration, vibration, and noise.

Commercial models are not expected to be available until next year, but the prototype is already in operation. Additional details will be presented in a forthcoming issue.



TEST BEARINGS will be placed on simulated motor-housing mount in new analyzer. Apparatus is essentially an electric motor with precise speed control, plus an extended shaft to drive the test units, and strain gages to measure torque loss.

Aluminum treatment to improve adhesive bonds

An inorganic paste cleaner for aluminum that is said to provide "an exceptional bonding base for adhesives" and to be "uniquely useful" as a means for securing a high level of adhesion with air-dry lacquers and enamels as well as baked finishes, is being readied for commercial introduction by Hughson Chemical Co., Erie, Penna. Besides removing dirt, it's said to react with the metal to form a thin, adherent, colorless film that promotes adhesion and improves wettability.

Hughson claims that treated samples of 2024-T3 Alclad develop shear strengths in excess of 4400 psi as compared to about 2400 psi for solvent-wiped control samples. (An amine-cured epoxy adhesive was used for the test.)

Proximity limit switch to be marketed

A switch designed to "detect any metal object without physical contact," and capable of sensing ferrous metals at a distance of one inch and nonferrous metals half an inch away, is being introduced by General Electric for use with both static and magnetic controls. Self-contained, fully transistorized and encapsulated, it is said to be unusually reliable and resistant to damage. Input rating is 30 volts dc; maximum repetitive accuracy, 0.005 in; maximum differential, 0.01 in. Operating time is 20 millisec.

New titanium alloys show high strength, oxidation resistance

By combining titanium with relatively large amounts of columbium and aluminum, it may be possible to develop a new family of alloys with high strength-weight ratios and excellent oxidation resistance.

In a report prepared for this week's Metallurgical Society (AIME) meeting, C. R. Simcoe and J. McAndrew of Illinois Institute describe several promising combinations.

Using columbium in percentages of 15 to 30 and 5 to 17½ aluminum, they've been able to produce alloys that resist oxidation at least to 1800 F, have densities of less than 0.181 lb/cu in. and show excellent strength-weight ratios in tests at 1600 F.

In stress rupture tests, one alloy showed a life of 100 hr at 13,000 psi and 1600 F; another had a life of more than 1000 hr at 10,000 psi and 1400 F.

Simcoe and McAndrew emphasize that these are single-specimen results. Much work remains to be done to find the optimum alloying percentages. —ARG

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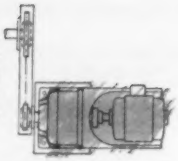

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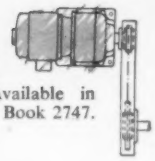

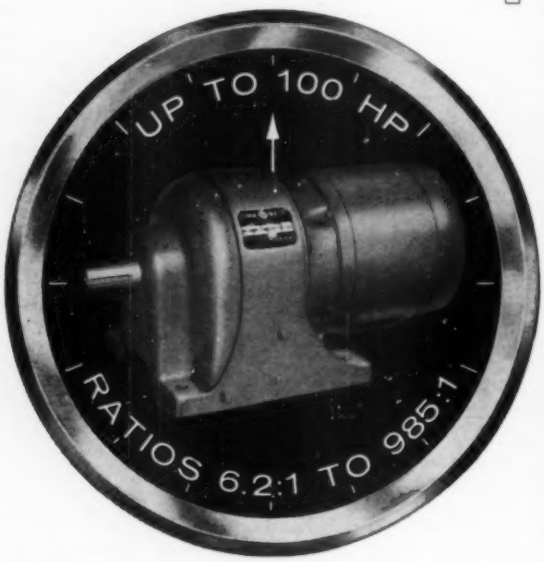

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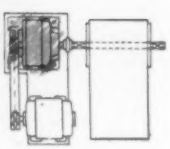

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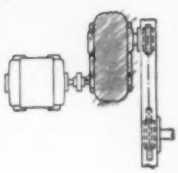

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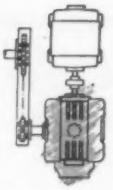

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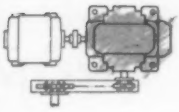

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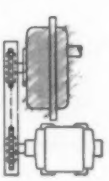

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FROM WASHINGTON . . .

Post office may cut R & E spending for equipment.

Research and engineering programs for the Post Office Dept are slated for a shakeup. Postmaster General J. Edward Day made it clear recently that federal financing of this research would be cut back. New equipment will still be sought, Day said, but after it has been developed.

Director of Research and Engineering, Wade S. Plummer, is resigning from the department. Other changes in R & E are in the mill. Mr Day has ordered that a hard look be taken by the department at all its research projects. Guessing is this will mean some will be cut from the budget. Some $12 million was programed for research in fiscal 1962 by outgoing Postmaster General Arthur Summerfield. It was a $2 million increase over 1961's budget.

Development of facsimile speed-mail program may be dropped. Reports are that industry is pressuring hard against the system. Little has been done on the project since last fall's test transmissions between Washington, DC, and Battle Creek, Mich.

Commerce studies industrial relocation

Five studies to relocate growth industries have been started by the Dept of Commerce. The investigation includes industries in electronics, fabricated plastics, scientific instruments, containers and electrical machinery.

Purpose of the studies is to aid expanding companies find new plant sites. The studies will include data on markets, raw materials, supplies, transportation, labor, etc, and are to be completed by midsummer.

Ebasco is conducting the study for fabricated plastics; Stanford Research Institute for scientific instruments; the Fantus Co for electrical machinery; Arthur D Little for electronics; and Galaxy Inc for containers.

Aluminum vessel proposed for oceanographic fleet

Oceanographic research will be pushed in Congress. Sen Warren G Magnuson (D-Wash) is backing a 10-year program designed to "match our reach into space for new scientific knowledge." And Pres Kennedy, in his State of the Union message to Congress, singled out oceanography as an area that had been neglected.

Magnuson's plan calls for construction of modern research vessels, more oceanographic research labs, and large amounts of scientific equipment. Favorable action is expected on the measure in Congress.

Navy is clearing the way toward construction of an all-aluminum submarine for oceanographic research. Dubbed the Aluminat, this sub will be built by Reynolds Metals Co and leased to the Navy. It will be 55 ft long and 7 ft dia, with a 6½-in. thick hull. Three to five persons could dive in the submarine to about 18,000 ft and remain submerged for 36 hours.

The vessel will maneuver vertically and horizontally at approximately 5 knots. Its cost will run about $2 million; it will take a year to build. It will have a closed-circuit TV system, and mechanical arms to collect ocean samples.

Navy will use the Aluminat to learn more about deep submarine operations and detection, with strong emphasis placed on underwater acoustics.

BEARING BRIEFINGS

One in a series of technical reports by Bower

ROLLER GUIDANCE– VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

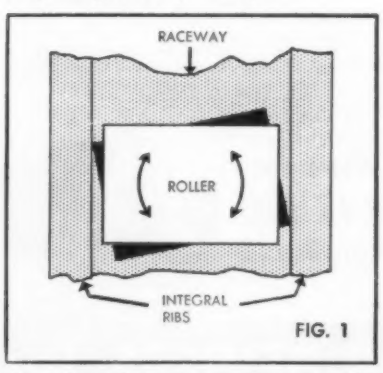
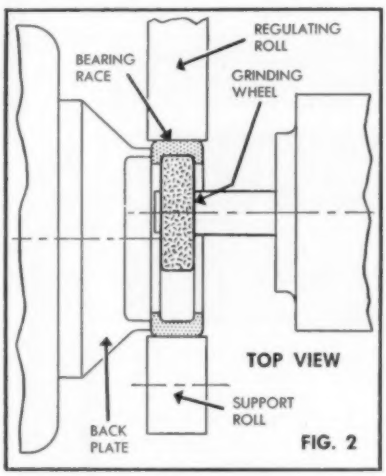
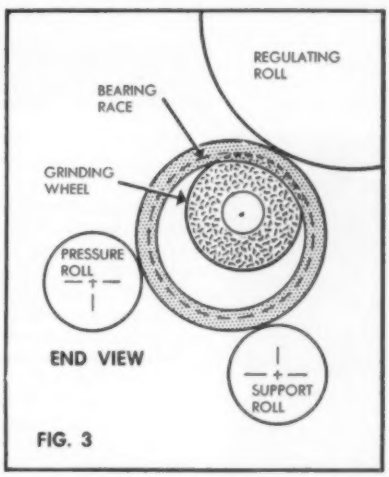


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.



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Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

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Oscilloscope photos show capabilities of Taylor Liquid Devices from the standard line

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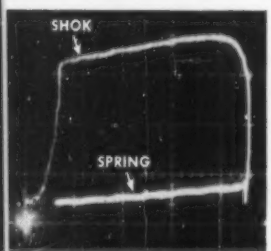
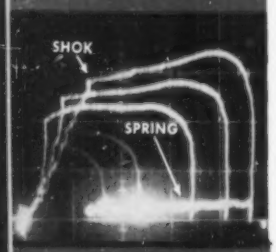
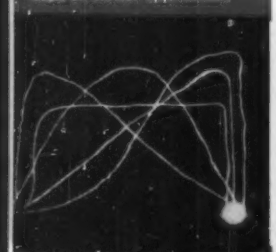


SPRING PLUS SHOK IN 1 UNIT
Used on aircraft arresting gear



MINIMUM IMPACT OR SHOK FOR ANY ENERGY INPUT CONDITION
Used on carrier applications



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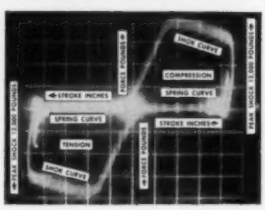
OSCILLOSCOPE photograph of the Taylor Tension-Compression Spring Shok shows energy absorbed under shock curve up to 80% of square card and spring capabilities to reposition fighter plane arresting hook shown at right. This unit provided 27.5 pounds weight reduction in 1/5th the space. Taylor Liquid Spring Shoks are designed to absorb and store energy in both directions. Double acting piston system uses same liquid to provide identical or different energy in tension and/or compression. Any desired shok or spring curve is available to meet exact requirements.



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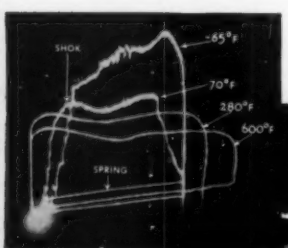

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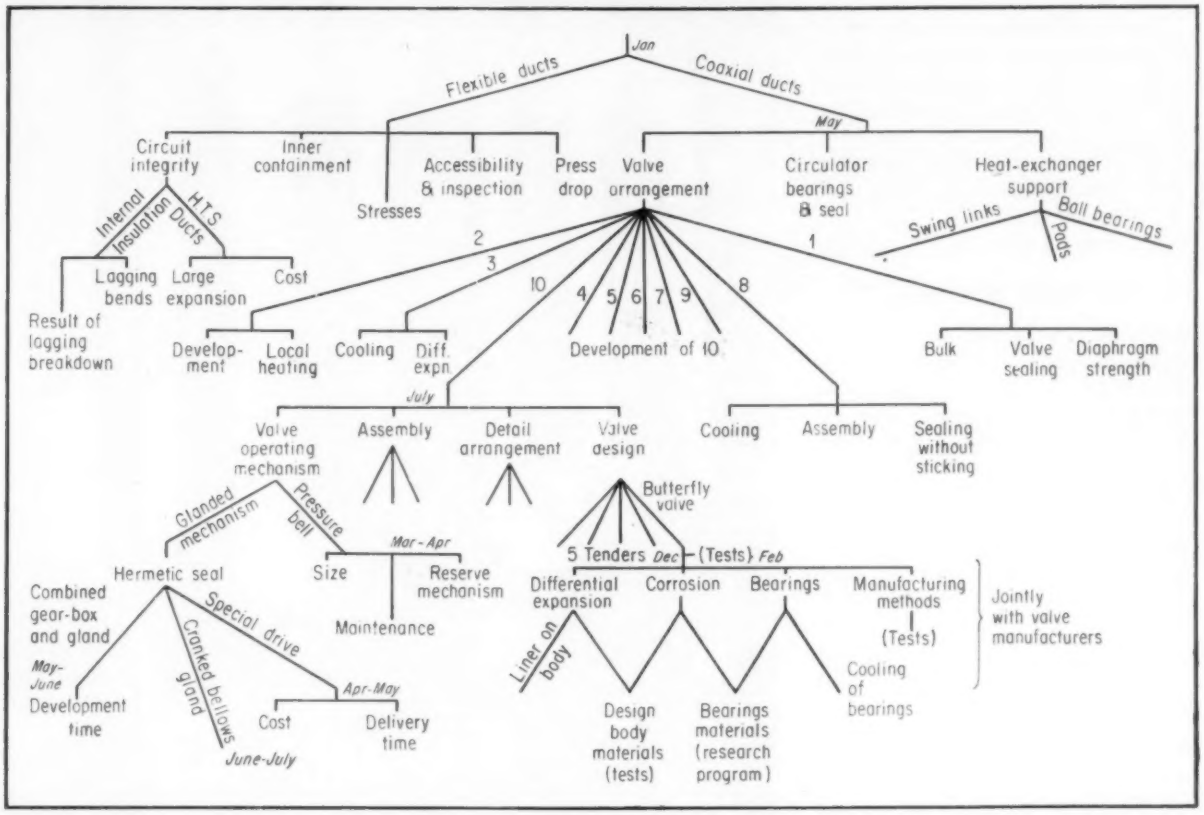
THE ENGINEERING WEEK



ONE COMPONENT—MANY PROBLEMS: This case study, part of a Cambridge instructor's way of teaching engineering design, illustrates the decisions required to design a duct-and-valve system for a gas-cooled reactor. Flexible ducts were ruled out early because breakdown of insulation would endanger the entire circulation system. The alternative, coaxial ducts, in turn raised subproblems which had to be allocated to various design teams: heat exchangers had to be lengthened, gas circulators integrated with heat exchangers, the entire housing for the reactor reshaped and valves designed. Chart here concentrates on decisions involved. Sloping lines denote possible solutions; vertical lines, the problems each alternative raised. Months indicate when decision on particular approach was made.

Design is Decisions and Not Intuition, British Teacher Finds

LONDON—British educators, like their US counterparts, are seeking better ways of teaching engineering design. Gone, they agree, is the time when design could be considered simply as "applied common sense" and when industry could rely on the few who had a natural flair for it.

One approach to the educational problem has been undertaken by D. L. Marples, a mechanical engineer and lecturer at Cambridge Univ. Under auspices of the Institution of Engineering Designers, he has carried out a study of decision-making in engineering design. The purpose of the study is to provide a generalized description of designing as a sequence of decisions starting with an original statement and ending with final hardware details. With such a description, Marples believes, the process of design can be taught—or at least shown—to students.

One of the case studies in Marples' analysis was a duct-and-valve problem for an advanced gas-cooled reactor. The design group, consisting of 70 engineers and draftsmen, considered two solutions to the problems: flexible ducts and coaxial ducts. The danger of breakdown of the ducts from insulation failure ruled out the first solution. The second solution, coaxial ducts, was then broken down into three major design problems. Each of these had alternative solutions, which in turn raised subproblems.

His study of how the 70 engineers attacked these subproblems led Marples to several conclusions. Designing, he found, is a sequence of critical decisions, which link it irrevocably with management. In making each decision, those responsible must consider various proposals, predict their outcome and predict the problems each solution will raise, including such considerations as availability of materials, compatibility with prior design, and difficulty of the new problems.

Tests, models and drawings, he found, relieve the engineer of excessive demands on his imagination, enable him to predict behavior of hardware and help him clarify associated problems.

Alternative solutions to problems raised at each stage can be examined in series or parallel. The parallel

method is preferred, Marples says, because it is faster, provides better insight into the particular problem and avoids personal bias of the engineer.

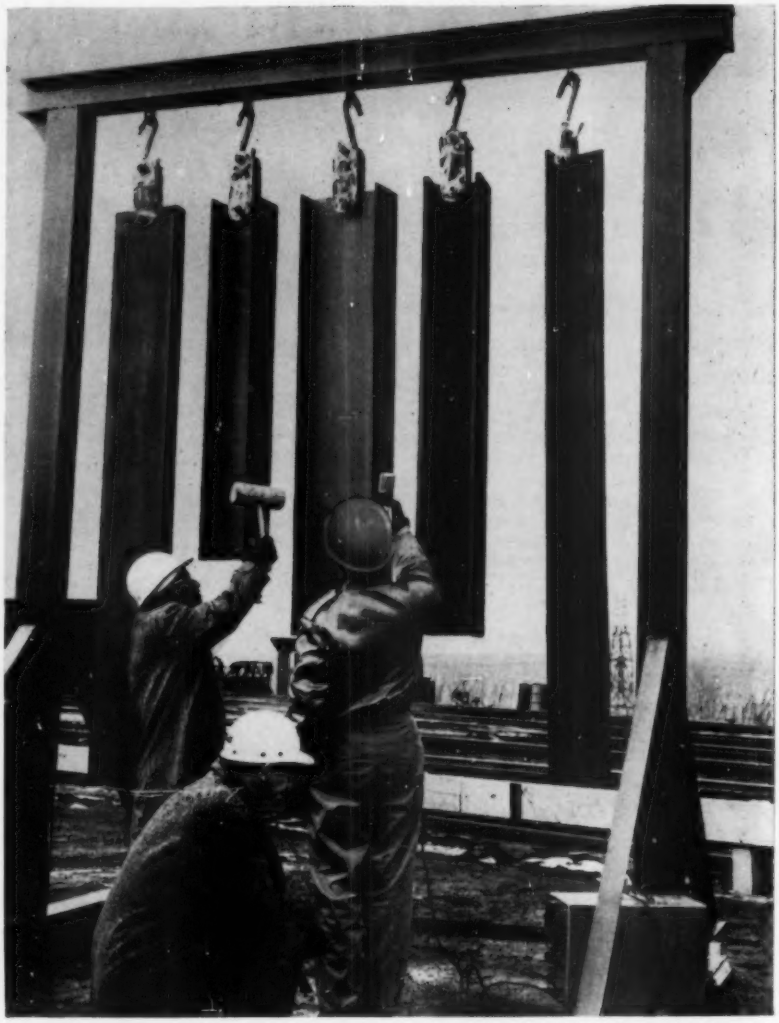
Finally, Marples concludes that novel solutions to problems are apparently obtained by using well-established methods and then finding new ways of solving subproblems. He found little evidence of intuitive flair in the cases he studied. ■

How to Strike an I-beam

RANGMATIA, E PAKISTAN—Engineers at Bethlehem, Penna, have solved a difficult problem here. It had to do with bells for local churches. Nobody in this part of the world makes them. A few have been imported from West Germany, but duty is 50% (the bells turned out to be steel rather than traditional bronze), and their sound doesn't carry. Several pastors tried the ends of acetylene tanks—very high pitched and no resonance. The loudest local "bell" (until recently) was in fact a 14-in. x 5-ft I-beam at the Catholic church in Tumilia, 10 miles east of the capital city of Dacca. Whence it came nobody knows, but it has been there for 12 years and can be heard for three miles even though it's cracked at both ends. It hangs from a cable between the church roof and a tripod on the sacristy roof.

There just wasn't any other I-beam around, new or old, and no way to handle it if there were. But the pastor of the local church was upset—

The new "bell," carried in by porters, at the church in Rangmatia.



Microphone and oscilloscope check sound of the "best bell," a 14-in. I-beam 6 ft. long. Channel, H and angle sections were also tested.

his 2000 parishioners heard the I-beam from two miles away more clearly than they heard his own. So he wrote to Bethlehem Steel, principally because he'd seen a huge bridge girder with "Bethlehem" stenciled on it during a visit home to Binghamton, NY, in 1953.

Bethlehem engineers, given the problem, were intrigued. They strung up various lengths of I-beams, angles, channels, T-shapes and wide-flange beams like meat in a butcher shop, and struck them with wooden, rawhide and rubber mallets, carpenter and beryllium hammers and steel sledges. Chemical compositions tested ranged from ordinary carbon steel to Mayari R, titanium steel and medium-manganese steel. An oscillograph and a pitch pipe helped determine resonance, overtones, pitch, clarity, loudness, retentivity and duration of sound. Plain manila rope, wire rope, wrapped hooks, bolts with rubber grommets, springs and other supports were tested. Holes were burned in flanges of heavier beams to cut dead weight, beams hanging horizontally from both ends like a hammock and from the center were tested too. One engineer who also plays the organ gave musical criticisms, using a tape recorder to make some direct comparisons and tests.

The results: Light, short sections were too "tinny," long sections too heavy to handle without equipment. Steel composition is not too important; all grades sound like church bells if of proper shape and proportions. The wide-flange beam is best; channels, tees and angles do not form a sufficient pocket for the sound to reverberate. Best size proportions: 12-

in. beam 5 ft long, weighing 135 lb; 14-in. beam 6 ft long, weighing 180 lb; 18-in. beam 8 ft long, weighing 560 lb. Best connection is a bolt with a rubber grommet, to avoid metal-to-metal contact. Best hanging is vertically. Best striker is an 8-lb sledge, which is solid enough to transmit the full force of the blow. The beam should be struck midway down, near the edge of the flange, to transmit bell-like overtones.

The section sent was the 14-in.-wide wide-flange beam 6 ft long, with a pitch of E flat below middle C. It has a "hearing radius" of three mi. ■

Custom-built Car Starts With 1020-hp Engine

CLEVELAND—Want to drive 250 mph? Want to own an exclusive "motor machine" rather than just a car? Whatever you call it, it is a 12-cyl, in-line, fuel-injection and supercharged 1020-hp, dual ignition engine. This is what the Argonaut Motor Machine Co here is offering to the world market, with delivery of the first car about a year away. Argonaut expects to produce 250 a year.

Richard S. Luntz, president, says his company will deliver to buyers any of seven motor machines ranging in price from the sportive model for $28,600 to a formal limousine at $36,000. Here is what the company will confirm:

Engine: The 1020-hp, in-line 12 has an aluminum block, aircooled, with 770-cu in. capacity. It is of "aircraft quality," uses 100-octane gasoline, and its power output is at 4800 rpm. Two overhead camshafts are used (no information available on stroke, bore, compression ratio or torque).

Transmission: A 2-speed transmission delivers engine power to the rear wheels. There is, according to Argonaut, "too much torque to make gear shifting necessary under most circumstances." Gears are reported to be made of unusual or exotic metals to withstand high speeds, but materials information is lacking.

Body: An all-aluminum body is planned, and according to Luntz, bodies for the first cars are ready for assembly to the frame. Special lacquers and coatings have been developed for finishes and final tolerances, says Luntz, "must be perfect since all parts are hand-fitted." No information is available on gages.

Chassis: The tubular 5-in. steel frame weighs 1060 lb. Wall thickness is reported at $\frac{3}{16}$ in. Frame is enameled white.

Wheels: 8.20 x 15 to 8.90 x 15 tires are planned, depending on the model. These are special racing tires, needed for the high speeds contemplated. Brakes are hydraulic—pedals on roller bearings—with stainless steel linkage and sintered iron linings.

Electrical: A 12-v nickel-cadmium battery is used, with an expected life of 15 years, in conjunction with an alternator. "Wiring quality shared only by jet aircraft," reports Argonaut.

General: Over-all weight is between 4000 and 5900 lb, depending on model. The sportive car, named Smoke, has a 126½-in. wheelbase and a tread of 66¼ in. Larger models are on 154-in. wheelbases with the same tread. Over-all length ranges from 212 to 258 in. depending on model. Exhaust system, instrument panel, 32-gal. fuel tank, hydraulic and fuel lines are all of stainless steel, says Luntz.

Some 19 stockholders own the company, and they plan an initial showroom in Cleveland, later in other areas. Ads run by the company in several newspapers recently produced several score inquiries, some 40% from overseas, according to the Argonaut firm's president. ■

Japanese R & D Stresses Atomic Progress

TOKYO—The Finance Ministry has authorized a request for $33 million to run the Science and Technology Agency here during fiscal 1961. The proposed budget—4% greater than fiscal 1960—will go to the Diet (Parliament) in March.

Almost ⅔ of the total budget ($21.1 million) has been earmarked for the atoms-for-peace program. Half of the atom studies will be carried out at Japan's Atomic Energy Research Institute.

Nothing spectacular is expected from atomic work during fiscal 1961, according to Masanosuke Ikeda, new minister of the agency. But, he says, Japan recognizes that it must take increasing responsibility for developing an atomic industry in the Far East. This will be particularly important, Ikeda believes, if Summit talks should ever reach a disarmament agreement, which would prompt an all-out effort among Far Eastern nations to push atomic power production.

The new minister added that inter-

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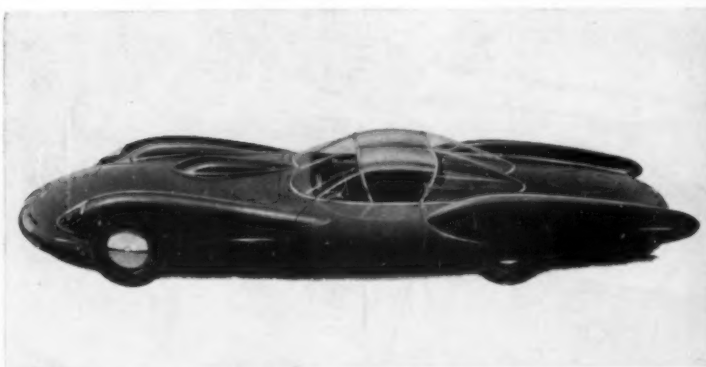
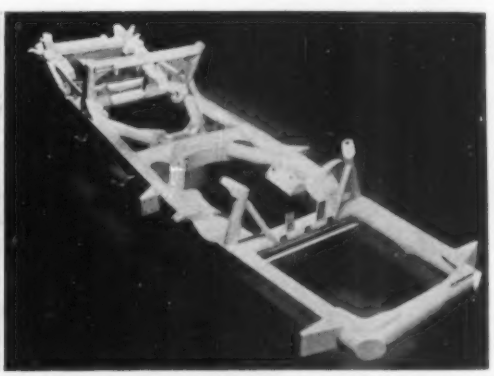


ARGONAUT MOTORS' "SMOKE" MODEL shows unusually low silhouette for its 12-cyl, in-line aircooled engine. Coachwork is handcrafted in Italy, and interior decoration and equipment is furnished to owner's specifications.



ENAMELED WHITE FRAME is at company's Cleveland works, awaiting first of handcrafted aluminum bodies. Frame and engine assembly are behind triple-locked doors and will not be publicly shown until assembled to body.

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FORWARD GEAR
PINION GEAR
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'61 Mercs are built to give the finest performance in our history—so we naturally depend on **G.S. Gears** for our transmissions!"

"I say 'naturally', because G.S. Gears are old friends at Kiekhaefer. We've used several millions of them in the Mercury motors we've built in the last twenty-one years—and they've given us a remarkable record of trouble-free power transmission."

Positive power control has always been a big "Merc" feature, whether in full forward-neutral-reverse types like the new 70 hp Merc 700 and 80 hp Merc 800, or direct reversing engines, the 70 and 80 hp Merc 700 and 800; so they are mighty concerned with the way transmissions hold up in actual use—and you wouldn't believe the tasks some customers will set for their Mercs!

That's why Kiekhaefer is glad to know that they can keep counting on G.S. Gears for the same quiet, positive gear action their customers are used to. It's that kind of satisfaction that brings customers back again and again when they're ready for new motors.

Of course, this reliability means a lot to the plant, too. Production men know they can keep right on rolling without slowdowns—the G.S. Gear sets are *right*, and they're ther when needed. You see, G.S. is strictly precision-mi ded—after all, we produce all kinds of gears from the hefty, heavy-duty bevels used in powerhouse outboards to tiny, delicate spurs for the most complex instrumentations. But we have production know-how, too, and the equipment and personnel to pour out gears in a continuous flow without wandering from specs. And G.S. experts are always available to work with your engineers on developing new ideas or better methods.

So, if your products involve small Gearing, you can't do better than to call in G.S. — it's great to have a source that keeps both your plant and your customers happy!

YOU'LL FIND G.S. GEARING IN TOP QUALITY PRODUCTS LIKE THESE . . .

Adding Machines • Aircraft Carburetors & Fuel Metering Systems • Aircraft Instruments and Radios • Automatic Musical Instruments • Automation Systems • Business Machines • Check Signing & Protecting Machines • Clippers for Barbers, Animal Shearing & Hedge Trimming • Cloth Cutting Machines • Coin Changers & Counters • Communication Equipment • Control Mechanisms • Electric Fans • Electric Motors • Floor Polishers, Sanders, Scrubbers, Sweepers • Food & Drink Mixers, Blenders • Home Appliances • Lawn Sprinklers • Machine Tools • Meat Tenderizers, Grinders, Slicers • Military Equipment • Motion Picture Cameras & Projectors • Optical Instruments • Outboard Motors • Pneumatic Production Tools • Radio & Radar Tuning Assemblies • Radio Anti-backlash Gears • Range Finders • Record Changers • Sewing Machines • Steel Strap Stretchers • Step Switches • Tapping, Drilling & Threading Equipment • Telephone Dials • Television Sets • Thermostatic Controls • Typewriters • Vending Machines • Washing Machines.

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WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING

continued from page 17

national exchange of atomic technology will be greatly emphasized in fiscal 1961. Japan will send 147 physics students abroad, and will send a science attache to Moscow in April. ■

Engineers' Pay Rises 5 Times Faster than Cost of Living

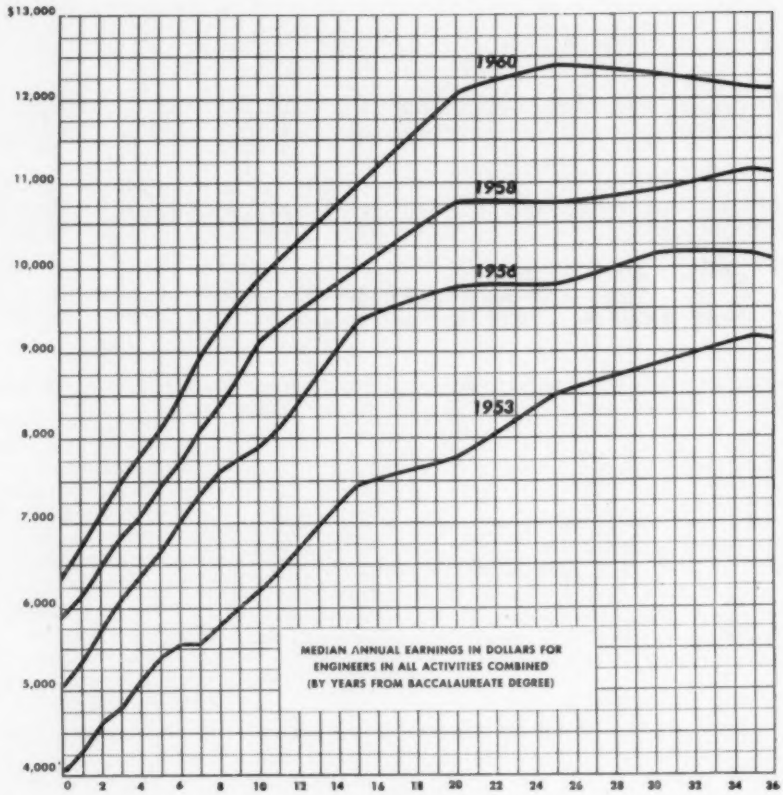
NEW YORK—Engineers are making steady economic progress. The median income for the profession has increased 49% over the past 7 years, comfortably outstripping a concurrent rise of 10% in consumer prices. Engineers have also improved their position relative to other groups in the economy. Average weekly earnings of production workers, for example, have increased 27% since 1953.

These observations, made by the Engineers Joint Council, are based on the fourth survey of Professional Income of Engineers. The survey, which put today's median income for all engineers at $9600, covered more than 190 thousand degree-holding technical persons in industry, government and education—roughly one-fourth of all practicing engineering in the US. The first survey in 1953 put the median salary at $6500. (The 49% increase between 1953-60 mentioned above includes a small adjustment for median years of experience of the groups between surveys (see chart at right for growth figures).

TOP DOLLAR IN INDUSTRY

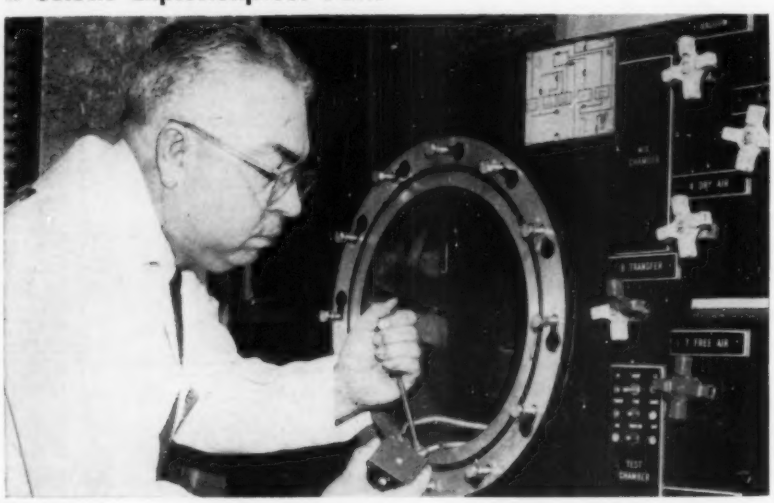
The EJC also finds that industry still pays better salaries than either government or education, though the level of teaching income has increased sharply—over 14%—since the last survey in 1958. The educators' income includes fees for consulting, which are generally substantial because of free time available to the professor during the summer and school vacation periods.

Among the 20 industrial subdivisions, highest median salaries are found in R & D, electrical machinery and aircraft; the lowest in railroads and mining. The median salary for an engineer in R & D just out of college is $6825 and advances to $10,275 for the professional with 10 years' experience. ■



Median earnings for engineering degree holders in 1960 show a 5%-per-year rise since 1958. This gain comes on top of the 6.5%-per-year shown in the two preceding surveys.

It Selects Explosionproof Parts



Small electrical devices such as circuit breakers, switches and motors are tested in this explosion chamber, designed to process parts which must be explosion-proof, before installation in Boeing Airplane Co's B-52H missile launcher. After insertion, air is removed from the chamber, which measures 12 in. dia and 15 in. deep, to create a vacuum. An explosive mixture is then fed into the chamber and the item being tested is put into operation. If the mixture ignites, then similar parts are rejected until the manufacturer makes them explosion-proof. The B-52H is expected to serve as the aerial launching pad for the new hypersonic Skybolt ballistic missile being developed by Douglas Aircraft.

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One Lamb FHP motor...up to 100,000 carbon copies mass-produced to exacting specifications

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If you have a special motor problem . . . here's what you can expect from Lamb! *Into the design* of a Lamb motor goes years of experience in powering components for aircraft, domestic and industrial products. *Out of the design* comes a personalized motor that's dependable, smooth and efficient.

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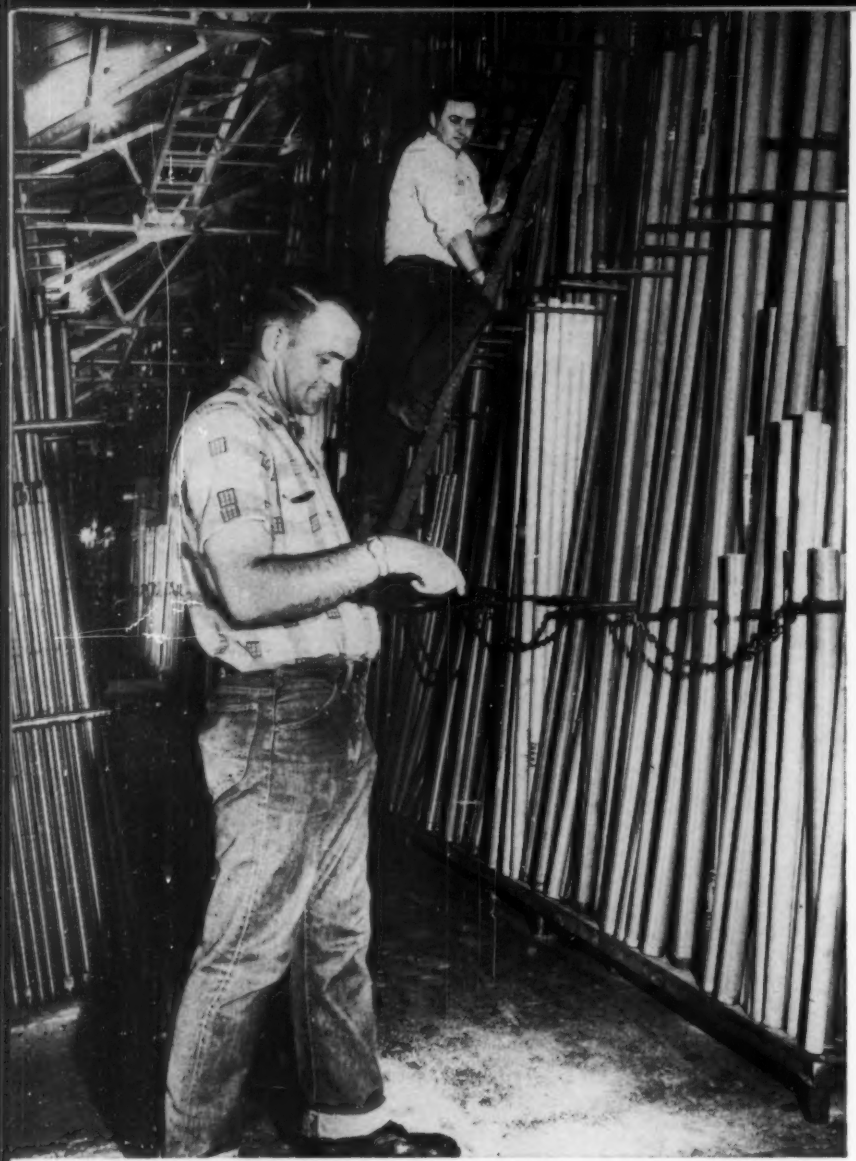


SEAMLESS STEEL BARRELS and other pump components of Harbison-Fischer's rod and tubing displacement pumps show great size range required to bring oil to the surface. Pumps vary on I. D. from ¾ inch to 5¾ inches; from 3 to 42 feet in length. Harbison-Fischer counts on commercial quality Pittsburgh Seamless Mechanical Tubing to get a 4 to 6 micro-inch I. D. finish with minimum clean-up expense.

Pittsburgh Seamless Tubes Give a Lift...

WHEN OIL MEN MAN THE PUMPS

When the gusher quits gushing and the oil flow slows to a trickle, it's time for oil men to man the pumps.

Pittsburgh Steel Company helps give them the lift they need with seamless mechanical tubing for sub-surface displacement pumps made by Harbison-Fischer Manufacturing Company of Fort Worth, Texas.

Nine of every ten producing wells must be pumped—and most depend on slender, precision-made rod and tubing pumps for efficient oil production. Harbison-Fischer has supplied them to the oil industry for more than 25 years—"The Best Pumps in the Oil Patch."

Among its eight types and wide range of sizes, there's a Harbison-Fischer pump to match every lifting job and well condition, whether it be depth, heat, pressure, corrosion or abrasion.

Pittsburgh Seamless Mechanical Tubing forms the pump barrel that contains plungers and valves. Besides destructive conditions below surface, barrels often must bear the weight (5 to 6,000 psi) of a fluid column of oil 10,000 feet or more deep.

● **Tight Specs**—To meet rigid API standards as well as its own manufacturing needs, Harbison-Fischer requires mechanical tubing with exact chemical and physical properties, and close tolerance I. D. and wall dimensions.

It demands tubing that is exceptionally straight, free of seams, laps and pits; made of steel that is machinable, and—in the high carbon range—fine grained and hardenable.

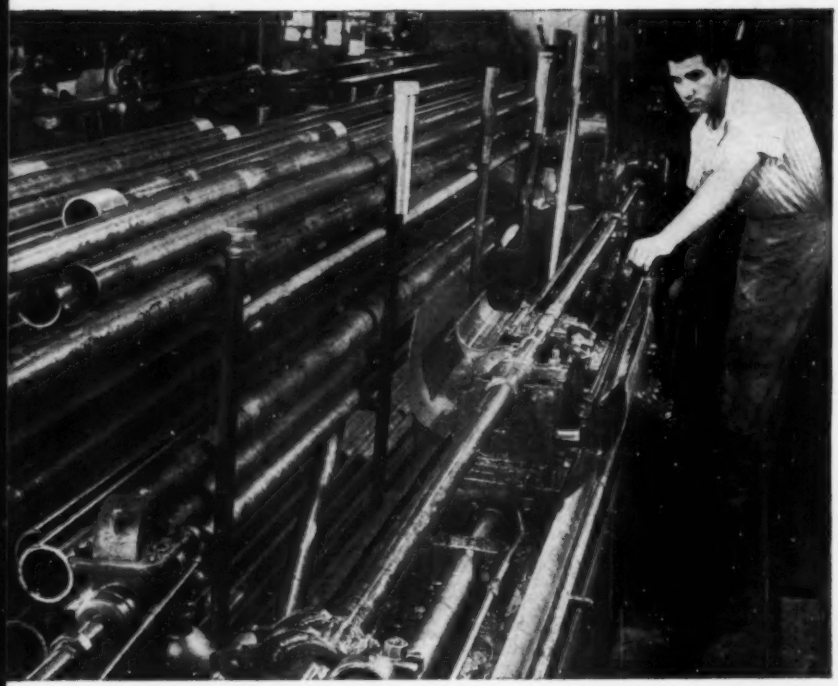
Pittsburgh Steel answers these requirements with mechanical tubing in C-1015 and C-1040 grades in commercial quality to help Harbison-Fischer hold processing to a minimum.

● **Fine I. D. Surface**—In production, Harbison-Fischer wants minimum stock removal to obtain a mirror I. D. finish and extreme straightness.

On its dozen long-stroke hydraulic hones, H-F holds the I. D. stock removal to a few thousandths of an inch. Says Harbison-Fischer:

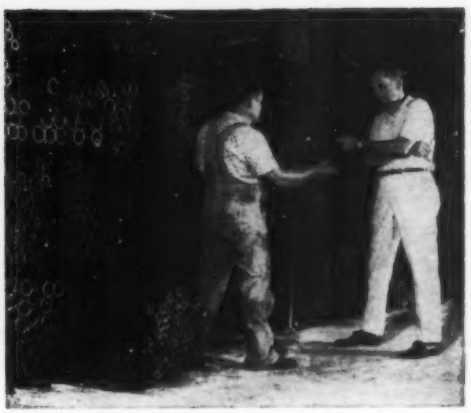
"The honed I. D. must be entirely free of pits. We want a four to six micro-finish. So you can see why the tubing's I. D. mill finish is important."

After threading and honing, every barrel is re-straightened to a tolerance of .015 TIR (total indicator



YOU CAN BE SURE WITH SEAMLESS. Straightness, close tolerance wall thickness and absence of seams, laps and pits in Pittsburgh Seamless Tubing mean fast, easy clean-up on horizontal hones. Minimum stock removal in honing tube's inner surface results in a mirror finish. Six-foot tube being set up here will become working barrel of two-inch tubing pump.

HONED TUBE GETS RIGID INSPECTION. Inspector uses I. D. micrometer to make certain barrel of 3-inch tubing pump stays within tolerance limits of —.0000/ +.0015 inch.



PRODUCTION PERSONNEL check wide variety of tubing used by Harbison-Fischer to produce "Best Pumps in the Oil Patch" for world-wide market.

reading) to overcome distortion caused by working of the tubing.

For installations where hard pumping and hard wear are factors, Harbison-Fischer heat-treats high carbon barrel tubing by an exclusive electronic process. The process penetrates the I. D. a predetermined depth to produce exceptional wearing quality, while permitting the O. D. to remain ductile and shock resistant.

Applications such as Harbison-Fischer's are typical of the uses to which Pittsburgh Seamless Tubing is put. There are thousands of them.

If you manufacture cylindrical products or parts requiring close tolerance, smooth surface or specific physical properties, you can be sure with Pittsburgh Seamless Mechanical Tubing. It can save you time and processing costs. Contact one of the district offices or distributors listed at the right. A Pittsburgh Steel representative will show you how.

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CIRCLE 23 ON READER SERVICE CARD

POINTS OF VIEW

THE QUESTION: *How Much Research Is Needed*

Research laboratories are employing more scientists and engineers than ever before in history. Where do these labs concentrate their efforts? What help can designers expect from these labs? In an exclusive interview, Dr Guy Suits, head of one of the world's largest research laboratories, takes you into the future.

Dr Guy Suits is a vice-president and director of research of the General Electric Co, and has been a member of the GE Research Laboratory Staff since 1930. He was born in Oshkosh, Wis and, in 1927, was graduated from the University of Wisconsin. While doing graduate work at Wisconsin, he worked as a consultant in the United States Forest Products Laboratory. There he developed new methods for measuring the moisture content of wood.

Awarded an exchange fellowship at the Swiss Federal Institute of Technology, Zurich, Switzerland, Dr Suits was granted the degree of Doctor of Science there in 1929. The following year he joined the General Electric Research Laboratory. Dr Suits now has over 70 patents in his name. Many are in the field of high-temperature arcs, including circuit interruption. In his experiments, Dr Suits has produced arc temperatures of 18,000 F. He has developed methods of measuring the temperature of arcs, and his comprehensive theory of this discharge has had much application in the practical problems of the understanding of switching, lighting, and welding-arc phenomena.—BAL

The basic strategy in planning industrial research is constant appraisal of scientific and technological opportunities and competitive factors. Let me discuss some of the opportunities now open to the industry with which I am associated. One big and growing item on the research horizon is the study of energy generation and energy conversion. This, I think, will continue to be an important activity and will have significant engineering impact in the next five to ten years. Developments in this field are not isolated technological developments. Whenever you improve the equipment per se you also obtain a multiplying benefit—because all industry employs energy.

Before discussing some of the newer energy-conversion work, we should remember that we are in an advanced stage of development of a major energy-conversion project—atomic power. This is important for many reasons, but particularly because atomic power does not employ fossil fuels—it taps a new energy source in uranium. We've seen how the tremendous energy of fission could be converted to useful power in the laboratory and in pilot plants; and we are now building full-scale powerplants.

The new atomic powerplants are based on the *fission* reaction. We should also remember that the atomic *fusion* reaction has been known somewhat longer than that of fission, and that extensive research here and abroad is exploring the application of fusion to power generation. This project is turning out to be unusually difficult, and in a sense, has gone back to the laboratory. During the decade ahead we will find out whether we have learned enough about thermonuclear reactions to make it feasible to start building powerplants. I would say that there is a somewhat better than 50-50 chance that within a 10-year period we can start building them.

The technical problems in fusion power are numerous; our basic problem, however, is designing a container which will hold a gas at a temperature of 100,000,000 degrees for about a second. This is not an easy task. Obviously,

for Engineering in the Sixties?

no physical container can fulfil these requirements. At GE, and elsewhere, we're trying to hold the gas in various types of magnetic fields. We've made progress, but quite a lot of work remains.

There are some other energy-conversion projects of major magnitude, but most of them relate to relatively old ideas. The fuel cell is in this category—it is an old idea that is being reappraised in the light of modern technology. The thermojunction is also an old idea, as is magnetohydrodynamic power generation. These ideas have long been in the minds of scientific and technical people—for hundreds of years in the case of the fuel cell and the thermojunction, and for about 50 years in the case of MHD.

What's Needed in Basic Research?

But while there is no doubt that industry is now engaged in a high level of effort in basic research, or simply, scientific research, I think the level could be higher in many cases. True, many industries have made scientific research a factor in business planning; but they have not yet become aware that science will be a factor in the future of their business.

For example, up to about five years ago, the metallurgical industries had almost no basic research. Recently there has been an upsurge of interest represented by new laboratories, new organization, and new programs. The industry is now allocating a significant effort to basic research. The automotive industry until recently had done practically no basic research. Now, the leaders in that industry are making a significant start in basic research. But there are large industries—like textiles, for example—where basic research is almost unknown. And significantly, recent progress in textiles has not been made by the textile industry, but by the chemical industry, as a result of its R & D effort.

How Much Money for Scientific Research?

You may ask what participation the smaller companies, with limited research capital, can make in this area. This question is best answered by the examples of progressive small companies that do a significant amount of basic research in fields related to their business. However, the feasibility of mounting a small-scale research effort depends upon the field. For example, it isn't feasible to undertake a program of thermonuclear research unless at least 10 senior scientists and extensive financial support over an extended period of years can be committed to the work. On the other hand, electronics research is typically done with bench-type facilities and limited resources. But even here the electronics researcher will often require supporting scientific skills, such as an analytical chemist, a metallurgist or a physicist, in the pursuit of his research program.

The actual cost for research again depends upon the industry. In the electrical industry, about 6 to 8% of the sales dollar is a typical expenditure for R & D. An interesting question, of course, is how much of the R & D total is actually basic research? At GE, we do not account for our basic research expenses separately. To tell the truth, the definition of the work, and its reduction to accounting practice, remain difficult. At the time I was chairman of the Naval Research Advisory Committee, it made a survey of basic research expenditures in industry as a percentage of R & D. The figure was found to lie in the range of 5 to 10% of R & D. Companies engaged in basic research seldom spend less than 2% or more than 10% of their total R & D for basic research; the average is about 5 to 8%. This is generally true of the chemical, electrical communications and electronics industries. Speaking now of R & D as an over-all activity, in the case of the aircraft manufacturers, they have always shown a very large R & D in relation to gross sales. The reason is that they include aircraft prototypes in their research expenditures. The pharmaceutical industry has always had a high ratio of R & D to sales, because of rapid product obsolescence, while the metals manufacturers would be very much lower on this same scale—generally in the range of 1%.

On a national scale we are not doing badly with respect to the amount of money being spent for R & D; however, there is room for improvement.

We could bolster many industry groups. The basic-metals industries have made a good start, and have a vast opportunity ahead of them. The automotive industry also has a tremendous research opportunity, and is underway. The machinery industry (including machine-tool companies) has many opportunities to develop new methods and materials. Is that good strategy? Wouldn't a broader technological base broaden the industry? Maybe this is one of the antidotes for overseas competition in this industry.

There is a limit, however, to what a company can afford to spend for research. There must be a balance between expenditures for future products, and present profits. A company must have some profitable business from which a portion of the profits can be diverted for developing new products and new business.

There have been cries that the US must undertake a crash research program. Here too we must identify the emotional issues and make sure that our future strategy as based on objective appraisals of opportunities in relation to competitive factors.

Designers think of R/M first for asbestos, rubber,

Poly-V "J" Light Duty Drive Gives You Design Advantages Never Before Possible

Most Revolutionary Drive for Small Sheaves, Short Centers, Compact Units

R/M POLY-V® "J" DRIVE is industry's newest and most revolutionary light-duty drive for small diameter sheaves, short centers and compact units. It utilizes a single parallel V-ribbed belt running on space-saving sheaves grooved to mate precisely with the belt ribs. Design advantages of Poly-V "J" add up to more dependable power in less drive space wherever balance and highly efficient, silent, vibration-free drive performance are required.

Advantages

- **Designed especially for small sheaves; considerably below V-belt range**
- **Silent, vibrationless, cool operation; homogeneous traction surface is spliceless, lapless**
- **No belt matching; a single belt cross section meets every need from 1/40 to 15 HP**
- **Delivers much more load in less space; permits more compact drive with smaller mounting clearances**
- **Exceptional flexibility; operates easily with midget motors**
- **Ideal for tandem, mule, ¼ turn or serpentine drives; with reverse bend idlers and for speeds up to 10,000 f.p.m.**
- **Minimum drive wear; assures longer belt and sheave life**
- **Absorbs shock; overload slip protection against machine damage**
- **Complete contact pressure; maintains groove shape**
- **Heat and Oil Resistant**

Poly-V "J" has been proved for smooth, silent power service on a wide range of small machinery—home workshop, machine tools, wash machines, lawn mowers, household appliances, and for many types of industrial, commercial and scientific machines.

For medium and heavy duty drives, R/M Poly-V* is available in the larger "L" and "M" Sections. These 3 Poly-V Belts (J, L and M) will replace 8 V-belt size sections and cover a power range from 1/40 to 1700 HP. Wherever your design problems involve power transmission drives, V-belts, flat belts . . . rely on R/M products and engineering.

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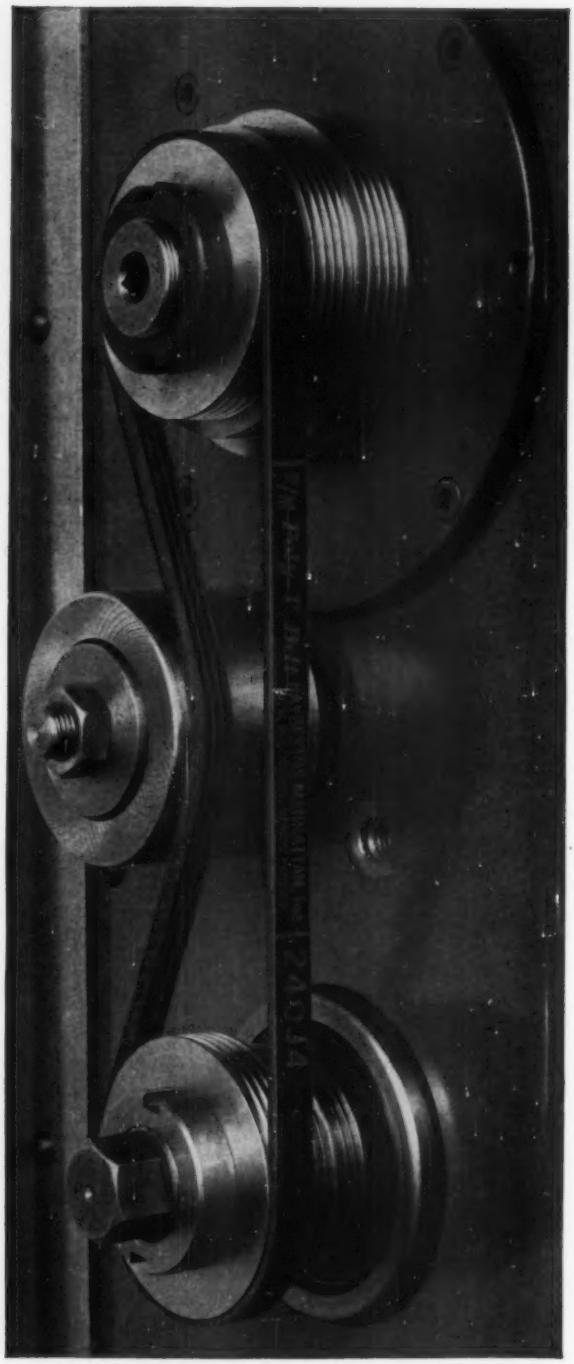
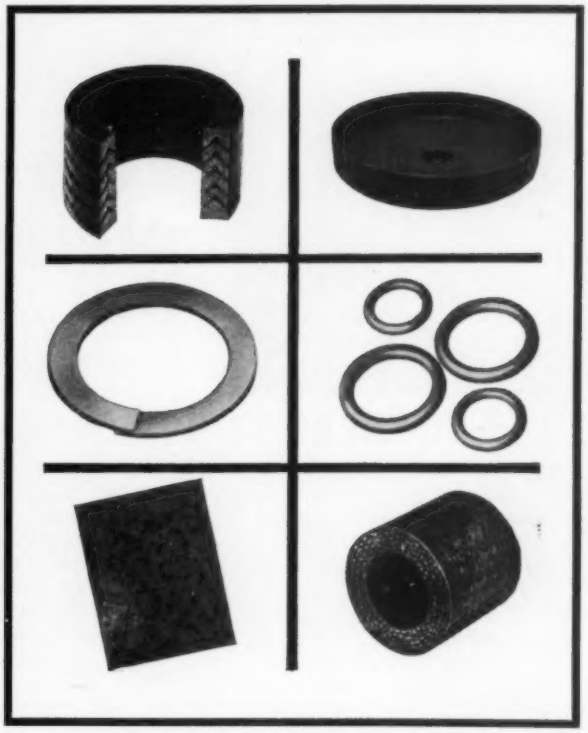


Poly-V "J" on Parker Majestic Grinder as standard equipment

sintered metal, and engineered plastic products



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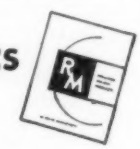

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CIRCLE 209 ON READER SERVICE CARD

CIRCLE 27 ON READER SERVICE CARD

MEEHANITE® MEANS BETTER CASTINGS

By W. H. MOORE
Vice President
Meehanite Metal Corp.

What you should know about Meehanite Metal

WHY THERE IS NO EQUIVALENT

How many times have you been told "I can give you something just as good as Meehanite® and at a lower price" only to find that the castings did not meet your standard of quality.

Actually there is no equivalent for Meehanite metal. Here's why: The exclusive Meehanite process makes use of 32 patented procedures that are essential to the production of highest quality castings and which can be used only by bonafide Meehanite licensees. These procedures relate to all phases of manufacture including processing agents, melting furnaces, sand control, and molding to insure the integrity exhibited by every Meehanite casting. More than 200 Meehanite foundries throughout the world prove the validity of these techniques and share in 35 years of technological know-how that truly puts Meehanite metal in a class by itself.

The production of Meehanite® involves a lengthy training period under the direction of Meehanite engineers, and a continuing program of metallurgical help and advice. Set standards of operation enable Meehanite foundry-men to apply structural control to castings on a day by day basis.

Essentially, the metallurgical control in the production of Meehanite castings involves obtaining a balance between undercooling produced in the melting operation and nucleation produced by processing the molten metal with alkaline earth agents. The initial degree of undercooling is related to the mass of the casting to be poured and the density and physical properties required. This is then modified by nucleation to force deposition of graphite at exactly the right time during solidification so as to give the right size and shape and distribution to the free graphite at the same time maintaining the character of the metallic matrix. The net result is predictable properties and uniform structure in every section of a casting and from casting to casting.

Gray cast iron made to a chemical specification without benefit of controlled undercooling is influenced by mass effect to a maximum degree and for this and other reasons cannot be considered an equivalent to Meehanite.

There are more than 26 different types of Meehanite metal available, each of which is specifically designed for a given set of service conditions.

Accept no substitute for Meehanite quality and performance. Specify Meehanite castings and be sure. For more information about Meehanite castings and the foundries making them, write to: *Meehanite Metal Corporation, 714 North Avenue, New Rochelle, New York.*

MEEHANITE METAL

Meehanite Castings Are Made Only By Meehanite Foundries

READER TO EDITOR

Introverts and Creativity

To the Editor:

Creativity, as usually interpreted, appears to carry the same picture-connotation characteristic as your discussion of "inventor-innovator" (Dec 12 '60, p 9). "Creative" is more apt to produce a mental picture of a musical note juggler, or the possessor of freak vocal cords, rather than an achievement in advancement of real material and physical welfare.

Over the past 25 years detailed observation of, and search for, personnel to create marketable products has developed a concern over the influence of extrovert-introvert characteristic misinterpretations similar to those of IQ-test and teacher-preference data mentioned in the article "Creativity." Much real progress seems to be lost in neglecting the approach of creating products (or advancements) which are so good that they sell themselves. Instead, we find an emphasis on "selling" (an extrovert cover-up of deficiencies) instead of "procurement" (introvert optimum-seeking). We find an abnormal proportion of management from the parasitic professions (the arts, law, and accounting).

It is pathetic that this nation has not cataloged the statistical expectations of standard analysis steel properties, for example. Try to find data on the holding power of sheetmetal screws (and who doesn't use them). The basic needs could go on and on—instead we enthuse over computers which produce cabinets full of data to be corrected by "development" (cut and try by mechanics because the design wasn't much in the first place) because mathematical-manipulative personnel deficient in the knowledge of fundamentals select the computation input.

It is unfortunate that we introverts cannot place this world in detail on a pedestal and laugh the parasitics and extroverts into a plan for progress. —HARRY KOTTAS
Momence, Ill

Defends Random-wave Vibration Tests

To the Editor:

In the recent article (Dec 5, 1960, p 82) entitled "How Good Are Random-wave Vibration Tests?" I agree with the author, Mr Stradling, that there is a controversy over random versus sine-wave testing and that sometimes too much emphasis is placed on the random-vibration test. However, an over-all curtailment of random-vibration testing is as much unjustified as proclaiming its exclusive use. Certainly each individual requirement has to be evaluated on its own merits. Many of Mr Stradling's conclusions do not follow from his premises or facts. For example:

" . . . simple sine tests give nearly the same information as random tests . . ." This is completely false. It has been shown both experimentally and theoretically that for a multi-degree-of-freedom system, no valid random-sine equivalence

exists, and therefore the results from these two types of tests generally cannot be related. The author also says, " . . . there is a difference between the vibration composed of a random selection of discrete frequencies and environmental vibration in which a broad band of frequencies occur simultaneously." This statement is meaningless in this context since to my knowledge no one ever found a "random selection of discrete frequencies" in aircraft and missiles and no one advocates using this. Mr Stradling states, "Never in my experience has any structure that failed with random, mechanically coupled vibration resisted failure under sine-wave vibration. The converse cannot be said." Obviously, if the vibration level is severe enough, anything is eventually going to fall apart, whether it is subjected to random or sinusoidal vibration. Before a failure under random vibration can be compared to a failure under sinusoidal vibration, a standard of equivalence has to be set up. There is considerable difference of opinion as to what constitutes the best criteria for equivalence. In addition, various criteria established to date apply only to single-degree-of-freedom systems. As mentioned above, recent investigations have shown that there is no general equivalence possible for multi-degree-of-freedom systems. —G Harold Klein

Ramo-Wooldridge Canoga Park, Calif

To the Editor:

Despite Mr. Klein's objections, I stand by my original contention that simple sine tests give nearly the same information as random tests and do it with much less trouble and much smaller investment in test dollars. To answer Mr. Klein in detail would require a restatement of arguments already presented. I refer interested readers to the article. —C G Stradling

Kearfott div of General Precision
Little Falls, NJ

COMING EVENTS

MARCH

9-10 . . . . Institute of Radio Engineers with AIEE & IAS, 2nd Symposium on Engineering Aspects of Magnetohydrodynamics, Univ of Penna, Philadelphia

12-16 . . . . American Society of Mechanical Engineers, Aviation Conference, Statler Hotel, Los Angeles

14-16 . . . . Society of Automotive Engineers, National Automotive Meeting, Sheraton-Cadillac Hotel, Detroit

20-24 . . . . American Society for Metals, 12th Western Metal Congress & Exposition, Ambassador Hotel & Pan-Pacific Auditorium, Los Angeles

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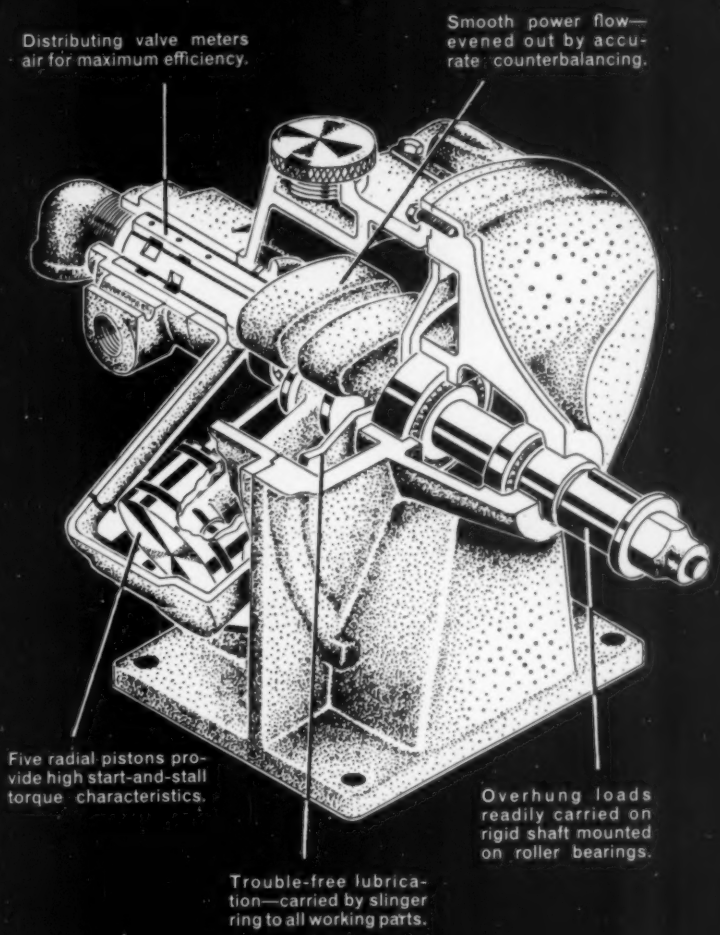
5-CYLINDER RADIAL AIR MOTOR—2 TO 16 H.P.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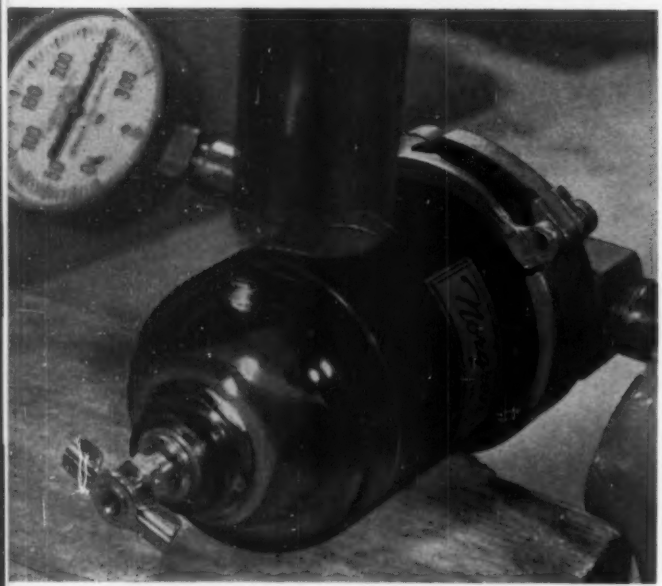
NEW NORGREN TRANSPARENT BOWL WITHSTANDS RIPPING IMPACT OF HOLLOW NOSE BULLET

Norgren "Safety-Green" bowl doesn't shatter... yet is fully transparent



Heavy steel bar dropped endwise from 12 ft. height merely scuffed surface of bowl carrying over 200 psi internal pressure.

Bowls for compressed-air-line filters and lubricators should be transparent to permit quick visual inspection. However, in the past, unusual or special applications often required the use of bowl guards or wire reinforcements ... sacrificing the advantage of transparency.

Now ... from Norgren ... you get a fully transparent, yet super-tough, impact-resistant bowl that won't shatter, craze or break—designed for even the most severe service. As these photos dramatically portray, the new Norgren bowls are completely transparent and are able to withstand conditions far more exacting than ever encountered in ordinary use. Non-shattering, unbreakable bowls mean reduced replacement cost, less air-tool and equipment down-time, savings in maintenance and operating costs, greater employee safety.

These new green shatterproof bowls are now available for most Norgren air-line filters and lubricators—or may be obtained separately for replacement purposes from your local Norgren representative or distributor. Or, write for full information.

As a further test of toughness, the new Norgren bowl was placed in a heavy machine shop vise ...

then compressed almost flat. Even in this extreme position, the bowl did not break or even crack.

Turned and squeezed again back to its original shape, the bowl still showed no cracking. Except for vise marks almost good as new!

...WITH NO SHATTERING!

Unretouched high-speed photo by University of Denver Research Dept. shows new Norgren Safety-Green Bowl a split second after penetration by bullet. Initial pressure of 265 psi is being relieved through bullet hole.

Specify Norgren "Safety-Green" Bowls

Large photo shows bowl after test. Only damage to bowl is clean bullet hole with no cracking, crazing or shattering. Impact has broken gauge. This test clearly demonstrates extreme toughness of Norgren Safety-Green bowls.

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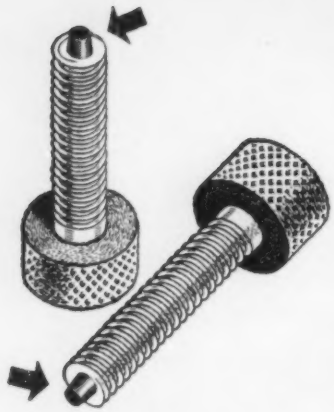


THESE PIECES OF KENTANIUM* INCREASE SERVICE LIFE 15,000%

Used to grip glass sheets as they pass through an annealing furnace, the Kentanium tips on these tong screws are subjected to temperatures of 900°F. to 1200°F. Yet they average 36 hours, an increase of 150 to 1 in service life over steel screws, which averaged one to three passes through the furnace.

Kentanium carbides have many properties for many applications—including some that may be the answer to your requirements.

PROPERTIES: Kentanium hard carbide alloys have high resistance to oxidation at temperatures of 2200°F. and above; the highest stiffness-to-weight ratio of any metal or alloy; high hardness; resistance to abrasion from 10 to 100 times greater than steel; high resistance to corrosion . . . plus high torsional, compressive, and tensile strength. Kentanium also has an extremely high YME—up to 60 million psi compared to steel's 30 million psi.

APPLICATIONS: Write for new Booklet B-666, "Proven Uses of Kennametal and Kentanium," which describes 80 different applications. KENNAMETAL INC., Dept. PE2, Latrobe, Pennsylvania.

*Trademark 33542

INDUSTRY AND KENNAMETAL ...Partners in Progress

FOR YOUR INFORMATION (personal)

Research—bite at a time

If you're having trouble finding high-strength materials for gears, pistons, and fasteners, you can at least console yourself with the fact that you've a material of your own that science can't match—tooth enamel. Its compressive strength is 60,000 psi; while the best man-made "substitutes" range downward from 40,000 psi (for amalgams) to 12,000 psi (plastics).

It's no consolation when you go to the dentist, but F. A. Peyton of the U of Michigan School of dentistry points out that fillings are literally a wide-open field for research. Needed are compositions that combine high compressive strength with low thermal conductivity, elasticity, corrosion resistance, and other characteristics that match the natural product.

More information is needed, too, on tooth grinding and its effects; and some new approaches are already being tried. Aerospace Medical Center, for instance, is using a "tooth-size" radio transmitter, which can be mounted on a dental bridge for insertion in the mouth to monitor number of closures, grinding action, and amount of stress. Varo Inc, makes the device, using micro-circuitry and a tiny mercury battery, encapsulated in resin to form a toothlike unit weighing 1.2 gm.

French shrink the camera again

A new 24 x 36 mm reflex camera, claimed to be the "smallest and best of its type," is being readied for commercial introduction by the Pierre Couffin Co of France. Called the Malik Reflex, it has a variable focus objective (35 to 75 mm), is just over 3 in. long and a little less than 2½ in. wide. Couffin hopes to have it ready for export by the end of this year.

Quick cure for car radios

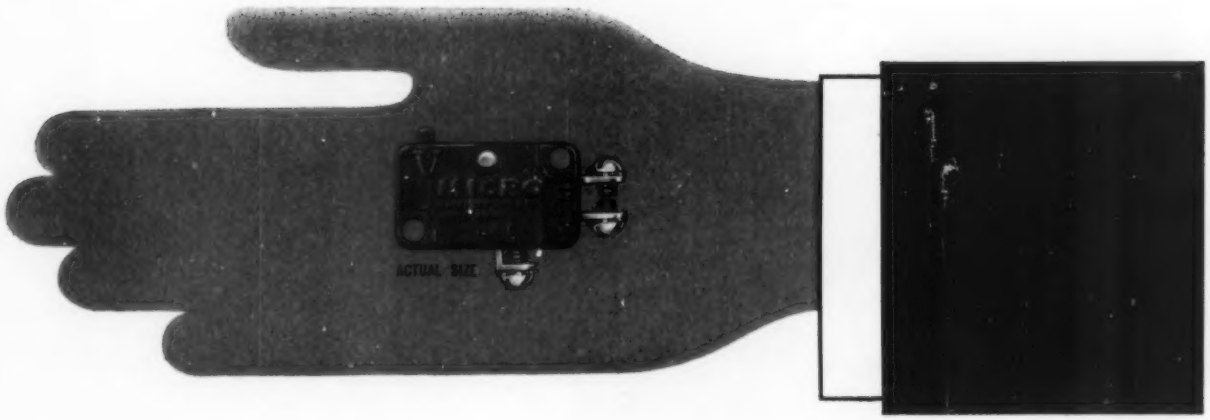
If there's too much noise on your car radio, and you've already isolated the ignition system, you can try painting the brake drums with graphite paint to provide a conductive path between chassis and brake linings. But researchers at Morris Motors, Cowley, England think they have a simpler solution that's nearly as effective, Britain's *New Scientist* reports.

Most of the trouble seems to come from the front wheels, they say—probably because the lubricating grease in the hubs and their stub axles insulates them from the chassis. So, all that's necessary is to establish an electrical connection at that point. That can be done by anchoring a steel-wire spring to the outer face of each front-wheel hubcap and drawing it through the venthole of the cap to make pressure contact on the end of the stub axle. Rotation of the wheel assures good contact by wiping the end of the spring against the axle, and keeping it clean and under pressure.

S.O.S. via self-speaker

Be it fire or felon, this British instrument should bring help on the run. Set to a standard emergency number, and carrying two pre-recorded messages plus its own 24-volt dc power supply, it can be connected to any type of burglar or fire alarm and do its own planning "in complete silence." Southern Instruments Communications Ltd, Camberley, Surrey, England is making it, calls it the "auto alarm dialer." Nickname: electronic stool pigeon. Price: £50 to £60 (about $150).

—ARG



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Single-pole double-throw
(With quick-connect terminals)

Single-pole double-throw

Single-pole double-throw
(Extra-long life, mushroom head plunger)

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... WITH NEW, HIGHER CAPACITIES! This versatile series of basic switches combines miniature size with new, higher electrical capacities. Switch cases and plungers are available in different plastic materials to meet varying requirements. Special high-temperature versions with synthetic mica cases withstand temperatures up to 600° F. Contact arrangements include double-throw, normally-open or normally-closed, with a choice of terminals. Models are available which conform to applicable requirements of Military Specification MIL-S-6743. "V3" Series basic switches are especially adaptable to multiple cam-operated gang-mounted systems and are also used as switching elements in many of our enclosures and assemblies. See the Yellow Pages for the nearby MICRO SWITCH Branch Office or write for Catalog 63.

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A new COMPUTER (the latest BENDIX Alpha-Numerical type) has enabled us to greatly accelerate our continuing program of basic research in both gear and broaching practice.

Another important advantage of this equipment is utilized in the day to day design of individual shaving cutters and honing tools to meet certain specified operating conditions. With the computer, all of the many design possibilities are rapidly evaluated in order to be sure of the very best selection.

Red Ring engineering know-how plus high-speed electronic calculation is your assurance of the most effective tooling for your own production needs.

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February 27, 1961

the Seven Swabians

Seven Swabians, according to the 150-year-old German story told by the Brothers Grimm, allied themselves to seek adventure. They had one long, strong spear made, which all carried, with Schulz, the bravest, in front, followed in turn by Jackli, Marli, Jergli, Michael, Hans and Veitli.

One twilight, a hornet hummed so close to Master Schulz that he was terrified, almost dropped the spear, and shouted, "I hear a drum." Jackli, just behind him, smelled something, and in turn cried, "Something is most certainly going on, for I taste powder and matches." At these words, Schulz did let go, leaped a hedge and landed on the teeth of a rake left lying in the hayfield. The rake handle flew up and hit his head, at which he cried: "I surrender! Take me prisoner!" All the others promptly leaped the hedge, and landed in a heap, shouting, "I surrender too!" When they at last realized their error, they agreed not to mention the adventure.

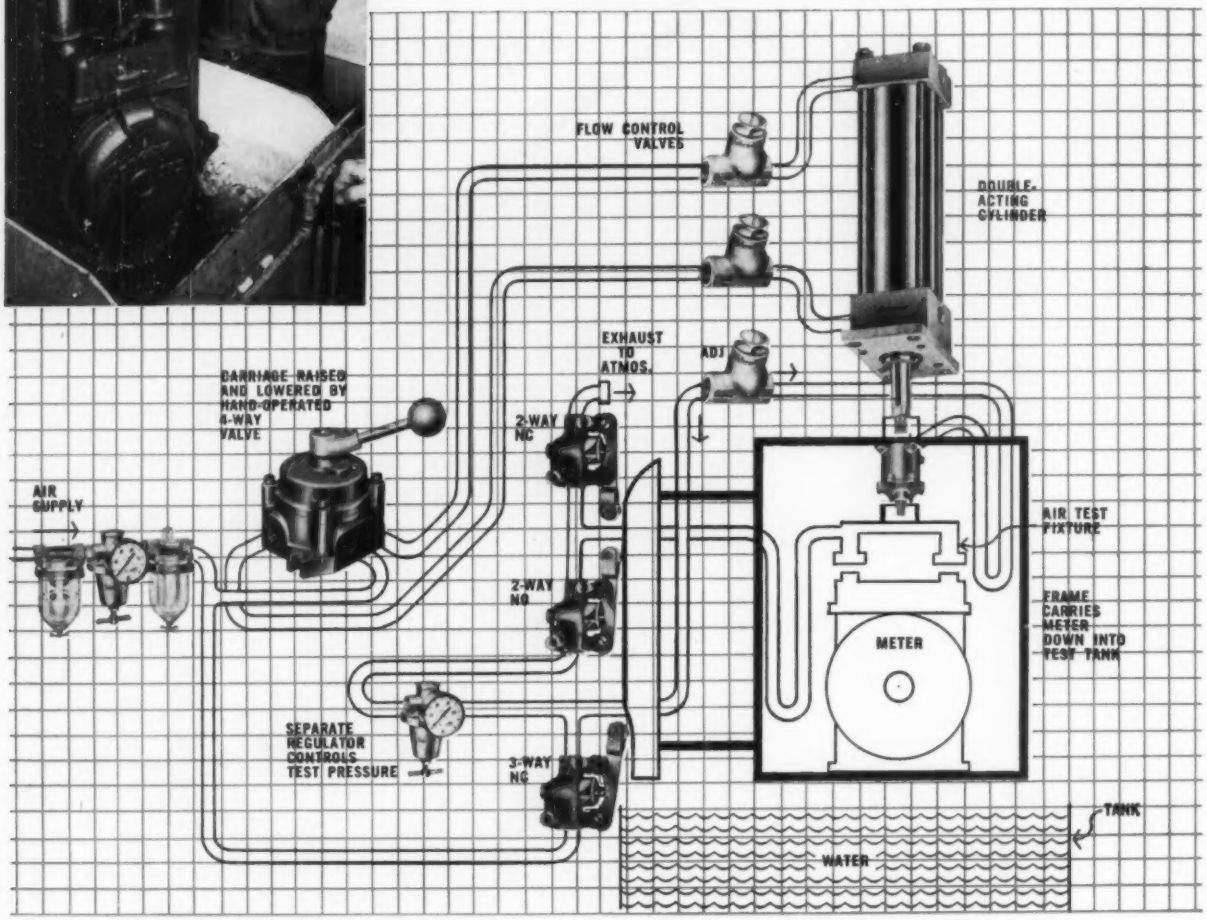
Some days later, they saw a hare sitting erect in the sun asleep, ears cocked up and eyes glassily open. All were alarmed at sight of this horrible wild beast, so they consulted to choose the least dangerous course of action. If they retreated, they were sure the monster would pursue and swallow them whole. So they said: "We must go through a great and dangerous struggle. Boldly ventured is half won." All seven grasped the spear and advanced, although the story explains that Schulz, in front, seemed to want to hold the spear back, while Veitli was so anxious to push it (and them) ahead that Jergli offered to change places with him. As they approached the "dragon," Schulz screamed in fear, alarming the hare, which darted away.

Thus, flushed with victory, they came to the Moselle River, where there was neither bridge nor boat. When they called to a man across the river for instructions, the distance and their dialect confused him, so he called back "What? What?" This they understood as "Wade, wade!" So Schulz began, and sank into the mud beneath the waves. But his hat floated across to the opposite bank, where a frog sat upon it and croaked, "Wat wat, wat." The other six heard this and said: "Oho, comrades, Master Schulz is calling us. If he can wade across, why cannot we?" So all followed Schulz' example—and were defeated by a frog.

This tale was obviously told by someone biased against both Swabians and committees, but who recognized that committees—of people, industries or even governments—are timorous.

F. Langenau

Here's how one company tests its products with air. This air circuit of Schrader Products at the Sprague Meter Company in Bridgeport, Connecticut, automatically clamps meter ports airtight, lowers meter into water, and fills it to test pressure. Operator looks for telltale bubbles from leaks, then presses lever to raise meter automatically. Says the Plant Manager: "This used to be a slow, arduous process. Now a meter's in the water, under pressure, in less than a second."



MANUFACTURER SETS UP CRITICAL TEST IN LESS THAN ONE SECOND— WITH SCHRADER AIR PRODUCTS

As products grow more complex and precise, many manufacturers are *simplifying* their operations—with air cylinders, valves, fittings and simple schematic planning. They're installing their own circuits, as this manufacturer did, or letting Schrader experts help. For example, Schrader Air Products can inspect, test, assemble, package—do work faster, more accurately—save effort and money.

Never forget air can make almost any motion human hands can—push, pull, hold, position, or move repetitively. And air doesn't get tired—has more powerful muscles. Maintenance? Almost nil.

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QUALITY AIR CONTROL PRODUCTS

which INSTRUMENT-GEAR MATERIALS wear least?

As precision requirements go up in the instruments field, gear wear must come down. To help you choose among the increasing number of gear materials, including plastics, here are results of wear tests. The gears were meshed in various combinations and operated under different conditions of lubrication and temperature.

R J BENSON, *Bell Telephone Laboratories, Whippnay, NJ*

New developments in metals, plastics, platings and surface treatments have made available to the designer a variety of gear materials with low rates of wear. The wide choice has come mainly in answer to demands for higher precision in instrument, servo-mechanism and data-transmission applications. Gear wear in such applications adds to backlash and angular errors.

For wear comparison, we performed a series of life tests on spur gears hobbed from a number of different materials. Sixty-eight pairs (meshes) of gears have been tested, and their wear determined by noting the increase in backlash with reference to elapsed running time. Backlash changes are indicative of wear, and from plotted backlash-versus-time curves we constructed a table giving the relative qualities of the materials tested.

Each pair or test mesh consisted of gears with a 20° pressure angle and 48 diametral pitch. The drive pinion had 48 teeth, and the driven gear 97 teeth. Each test setup accommodated four gear meshes. All gears were hobbed to full depth involute form, had a 0.250-in. face width, and were AGMA Precision Class 1. This class of precision indicates that the gear pairs have a maximum total-composite-error of 0.001 in. and a maximum tooth-to-tooth composite error of 0.0004 in.

The gear materials

Various combinations of gear materials and surface treatments tested during the program include:

- **Aluminum**—untreated, anodized, electrolized and chrome-plated.
- **Steel**—(stainless) untreated and electrolized.
- **Rulon B**
- **Nylon 3001**
- **Nylasint**—six compositions: Nylasint 64, 66, 64-6G, 66-6G, 64-MS, 66-MS
- **Sinite D-10S**

See the table on the next page for specific mesh combinations that were tested. The gears were operated with and without externally applied lubrication. Some materials have built-in lubrication; these are listed with the unlubricated groups because no external lubrication was applied.

Aluminum gears were machined from Type 2024-T3 alloy. This material has good strength and machining qualities.

Steel gears were of stainless steel Type 416, heat-treated to Rockwell C 25-30 before machining.

Rulon B is a plastic-bearing material. Its manufacturers have compounded or modified Teflon to produce a new product. The gears were hobbed from extruded rod.

Nylon gears were hobbed from nylon Type 3001 (similar to Zytel 31).

Sinite D-10S is a self-lubricating bearing material comprising 50% dry lubricative pigments and 50% bronze and tin powders. The dry lubricants are graphite and molybdenum disulphide, which are fused with the metallic materials. Sinite has mechanical properties and appearance similar to Oilite, a well-known bearing material. After hobbing, the Sinite gears were impregnated in a bath of Dow Corning 510 silicon oil (recommended by the manufacturer) for 30 minutes at 200 F.

Nylasint is a tradename referring to a group of sintered nylon products. This material is manufactured by

text continued page 39

REPRINTED—Circle 588, inside back cover

RELATIVE WEAR OF GEAR-MATERIAL COMBINATIONS

(Bold face denotes top performers; tests were scheduled for either 2000 hr, or for 480 hr at a higher operating speed—other figures indicate mesh was removed because of excessive wear.)

Unlubricated Gear-meshes

48-TOOTH PINION	97-TOOTH GEAR	HOURS RUNNING	INCREASE IN BACKLASH, IN. (WEAR)	RELATIVE WEAR, FROM 1 (BEST RANK) TO 68
Aluminum	Aluminum	421	0.0172	66
		421	0.0107	53
Anodized aluminum	Aluminum	2000	0.0181	67
		2000	0.0244	68
	Anodized aluminum	1156	0.0129	65
		1156	0.0124	64
Electrolized aluminum	Aluminum	300	0.0084	48
		700	0.0113	58
	Anodized aluminum	600	0.0112	57
		600	0.0109	54
	Electrolized aluminum	96*	0.0120	61
		138*	0.0076	43
	Stainless steel	2000	0.0031	37
		1000	0.0122	62
Chrominum-plated aluminum	Chromium-plated aluminum	2000	0.0010	22
		2000	0.0011	23
Stainless steel	Aluminum	2000	0.0071	42
		2000	0.0092	49
	Anodized aluminum	2000	0.0011	24
		2000	0.0011	25
	Chromium-plated aluminum	2000	0.0098	51
		2000	0.0080	45
Electrolized Stainless steel	Aluminum	1000	0.0079	44
		1000	0.0080	46
	Anodized aluminum	2000	0.0123	63
		2000	0.0112	56
	Electrolized aluminum	480*	0.0022	34
		480*	0.0009	20
	Stainless steel	**2000**	**0.0008**	**17**
		2000	0.0082	47
Rulon B	Anodized aluminum	700	0.0106	52
		700	0.0093	50
Nylon 3001	**Anodized aluminum**	**2000**	**0.0008**	**13**
		2000	**0.0008**	**14**
Nylasint 64	**Anodized aluminum**	2000	0.0012	26
		2000	**0.0005**	**6**
66	**Anodized aluminum**	**2000**	**0.0009**	**18**
		2000	**0.0007**	**10**
64-6G	**Anodized aluminum**	2000	0.0017	30
		2000	**0.0010**	**21**
66-6G	Anodized aluminum	2000	0.0022	33
		2000	0.0024	36
64-MS	**Anodized aluminum**	**2000**	**0.0009**	**19**
		2000	**0.0008**	**15**
66-MS	Anodized aluminum	2000	0.0012	27
		2000	0.0017	31
Sinite D-10S	**Anodized aluminum**	**2000**	**None****	**1**
		2000	**0.0006**	**8**
	Stainless steel	**2000**	**0.0007**	**9**
		2000	**0.0002**	**2**

Lubricated Gear-meshes

48-TOOTH PINION	97-TOOTH GEAR	HOURS RUNNING	INCREASE IN BACKLASH, IN. (WEAR)	RELATIVE WEAR, FROM 1 (BEST RANK) TO 68
Aluminum	**Aluminum**	**2000**	**0.0007**	**11**
		2000	**0.0003**	**4**
Anodized aluminum	Aluminum	2000	0.0020	32
		2000	0.0013	29
	Anodized aluminum	**2000**	**0.0008**	**16**
		2000	0.0012	28
Stainless steel	**Aluminum**	**2000**	**0.0007**	**12**
		2000	**0.0004**	**5**
	Anodized aluminum	**2000**	**0.0002**	**3**
		2000	**0.0005**	**7**
Gears Subjected to Temperature Variations, −65 F to 200 F				
Aluminum (lubricated)	Aluminum	480*	0.0068	41
Anodized aluminum (lubricated)	Anodized aluminum	383*	0.0117	59
Stainless steel (unlubricated)	Aluminum	238*	0.0120	60
	Anodized aluminum	238*	0.0111	55
Stainless steel (lubricated)	Aluminum	480*	0.0031	38
	Anodized aluminum	480*	0.0022	35
Nylon 3001 (unlubricated)	Aluminum	480*	0.0048	40
	Anodized aluminum	480*	0.0045	39

* Pitch-line velocity 471 ft/min.; all others 113 ft/min. ** No measurable backlash

cold-pressing nylon powders and sintering below the melting point. The sintering medium used on the test-gear material was Meprolene, a well-known heat-transfer oil.

The Nylasint 66 materials have the same chemical structure as nylon FM10001, while the Nylasint 64 materials are combinations of nylons, with FM10001 as the major constituent. Types 66-6G and 64-6G have graphite added; the 66-MS and 64-MS have molybdenum disulphide added to the basic material to impart certain properties. Because Meprolene is a good heat-transfer medium but a poor lubricant, the gears made from Type 66 and 64 materials were immersed in acetone after hobbing—to leach out the Meprolene oil. These gears were then impregnated in a bath of lubricating oil (SAE 30) at 200 F for 30 minutes. The Nylasint gears containing graphite and molybdenum disulphide received no such treatment.

Surface treatments

Anodizing indicates that the gears were subjected to a chromic process after machining.

Electrolizing applies an additive finish to the outer surface of the base material. The finish as deposited is approximately 90% chromium and has a Rockwell hardness value of C 70-72.

Chromium-plated aluminum gears were plated by the Hardalume process, a procedure developed by Tiarco Corp., Clark, NJ. With this process, the chromium layer is applied directly to the aluminum without any other intervening metal or anodic film. This process avoids cumulative errors in plating thickness which could become excessive and destroy the initial gear accuracy. Also, it avoids preplating, which may produce an undesirable electrolytic couple.

After machining, all gears to be anodized, chromium-plated, or electrolized were measured over pins. They were then surface-treated as required, and measured again. Anodizing decreased the measurements over pins by an average of 0.0001 in., with a consequent reduction in tooth thickness.

Electrolizing, on the other hand, caused an average increase in over-pin measurements of approximately 0.0002 in. Plotted curves of the measurements showed that the alloy was not deposited uniformly and in some cases exceeded the maximum limit established for this dimension.

Chromium plating also increased the measurement over pins for all gears. Plating was uniform in most cases.

Lubrication of teeth

A Mil G-3278 grease (Beacon 325) was chosen wherever lubrication was indicated for the test meshes. This general-purpose lubricant has a temperature range of −65 to +250 F. It was applied to the teeth of both pinion and gear before the start of a test; the meshes were then manually rotated and excess lubricant removed. This was the only application during the test.

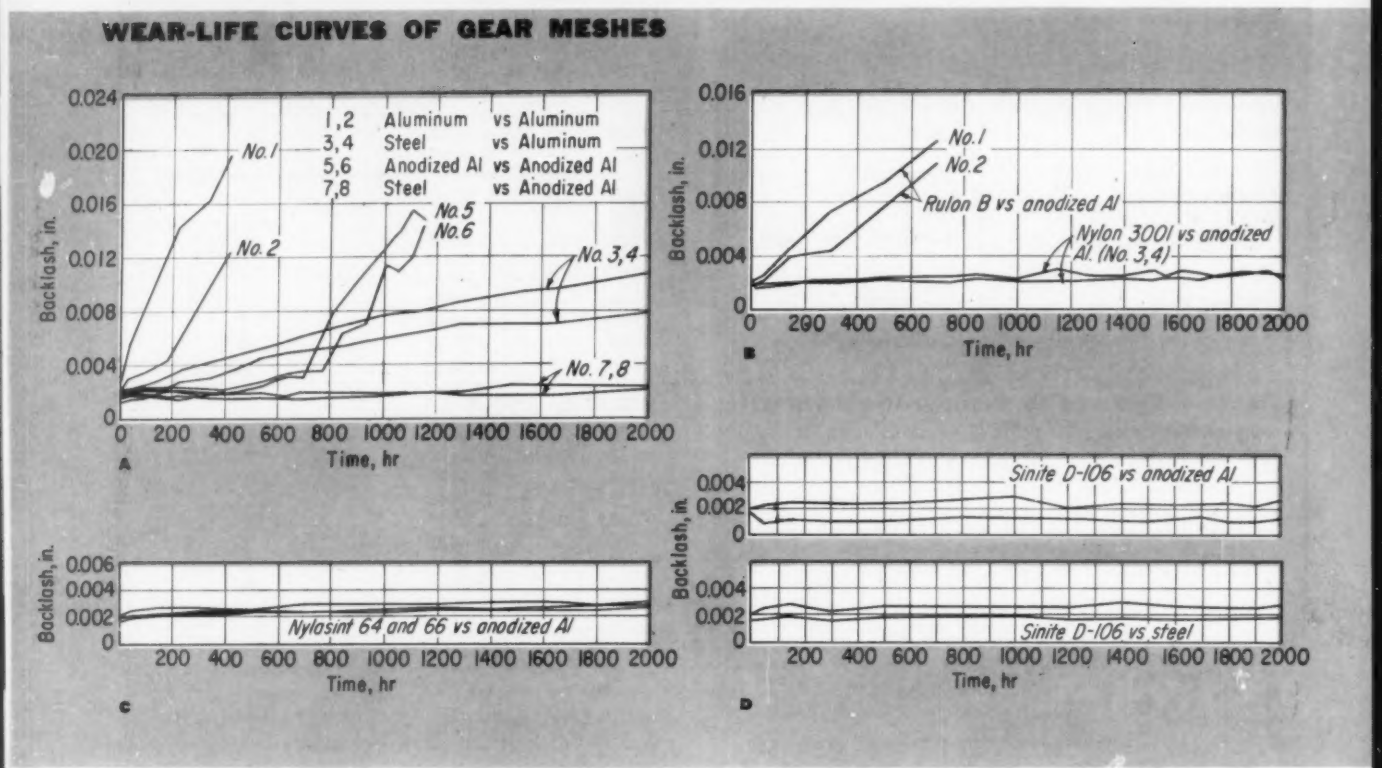
Operating speeds

Most gears were operated with an average pitch-line velocity of 113 ft/min.—others (noted by an asterisk in the table) were operated at 471 ft/min. When operated at 113 ft/min., the drive gears were rotated at 3450 rpm for one hour, then rotated at 300 rpm for 23 hours. The rotational direction was reversed every 4½ minutes with a 30-sec delay period between reversals.

To obtain 471 ft/min., the drive gears were rotated at a constant speed by a 1800-rpm synchronous motor. The rotational direction was reversed every 5 minutes with a 20-sec delay period between reversals.

Backlash measurements

Backlash measurements were taken with a 24X microscope mounted on a micrometer slide (photo next page). A



fixture with a 4-in.-long bar was attached to the driveshaft; the driven gear was held fast to prevent rotation. Deflection at end of the bar, when a torque of 200 gm-in. was applied, was converted to backlash in inches at the pitch line of the gears.

The average of three such readings taken equidistant along the pitch circle of the 97-tooth gear constitute the backlash reading for the test mesh.

Tests with temperature variations

One group of gears were subjected, while operating, to high and low temperatures inside an environmental test chamber. The motor was mounted outside the test chamber and the gears driven by a driveshaft coupled from motor with a universal joint and flexible coupling.

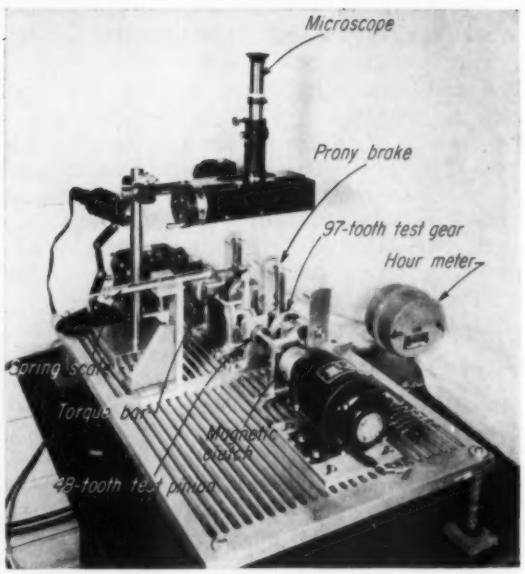
Temperature extremes to which the gears were subjected were −65 F and +200 F—one temperature cycle per 24 hours. Temperature of the gears was lowered to approximately −65 F and held for one hour, then increased to +200 F and held there for one hour, and finally, lowered to room temperature of about +75F. Temperature data were taken by means of a copper-constantan thermocouple attached to the test setup adjacent to the gears. Measurements to obtain backlash were taken at room temperature.

Gear-tooth loading

To simulate conditions of loading, the 97-tooth gear of each test mesh was loaded by means of the prony brake with a torque of 200 gm-in. This was maintained on all meshes throughout the running time of the life test.

The torque loading of a test mesh is converted to a value of compressive stress by use of Dudley's equations (*Practical Gear Design* by Darle W. Dudley, pp 48-50) which in turn are derived from studies made by Hertz.

Some computed compressive-stress values were: all-stainless-steel mesh = 9150 psi; all-aluminum mesh = 5670 psi; stainless steel versus aluminum mesh = 7868 psi. The equations do not take into consideration such factors as surface treatment, surface finish and lubrication.



TEST SETUP for loading and measuring gear wear.

Relative wear of gear materials

Backlash measurements were taken at appropriate intervals of time during the test and data plotted. The table gives the relative wear of the gear meshes, both for nonlubricated and lubricated conditions. This can be used to estimate the wear life of a gear mesh involving these materials. The "increase in backlash" shown in the table is directly proportional to wear and is between initial and final backlash measurements. Key conclusions from these tests are:

Sinite D-10S gears showed superior wear properties—these gears were meshed with anodized aluminum or stainless steel gears. One mesh gave no measurable increase in backlash—this was the best performing mesh. The low rate of wear of Sinite meshes is undoubtedly caused by the inherent lubrication (oil, graphite, molybdenum disulphide) rather than basic material characteristics.

Anodizing the surface of aluminum gears greatly reduced wear—this is interesting to note because aluminum gears are frequently used where inertia is a problem and lightweight materials are desired. Without anodizing, the aluminum gears gave generally unsatisfactory wear performance.

Lubrication of gears also reduced wear—although applied only once during the test. Meshes that fail under ordinary conditions, such as a mesh of unanodized aluminum gears, give good wear life when lubricated.

Unplated stainless-steel pinions meshed with anodized aluminum gears gave excellent results.

Plastic gears showed excellent wear life—these were the Nylon 3001, Nylasint 64, 66 and 64-MS gears. They had approximately the same rates of wear.

Rulon B gears gave unsatisfactory performance—but the wear was primarily on the anodized-aluminum gears rather than the Rulon pinions.

Electrolized-aluminum gear pairs gave poor wear results—unsatisfactory performances were also obtained with electrolized-aluminum gears meshed with anodized aluminum or unanodized gears: such pairs showed rapid and large increases in backlash.

Electrolized stainless-steel pinions performed satisfactorily with electrolized-aluminum gears—but poorly with anodized-aluminum gears. The tests showed that electrolizing the steel pinion of a steel versus aluminum mesh does not decrease the wear rate—in fact, wear is greater.

Electrolized aluminum gears meshed with stainless steel gears gave a wide variance in results. A similar situation exists with the combination of electrolized steel pinions meshed with steel gears. On the basis of these test results neither of the two material combinations should be used.

Chrome-plated aluminum gears meshed together have excellent wear properties. On the basis of previous life tests this combination exhibited far better wear properties than any other all-aluminum mesh, regardless of finish. Using an all-aluminum mesh offers distinct advantages where minimum weight is desired.

Chrome-plated aluminum gears meshed with stainless gears gave poor results. This combination is not satisfactory for gearing.

Temperature cycling tests showed that the lubricated mesh of a stainless-steel pinion and an anodized aluminum gear wore the least. The anodized gears again showed less wear than unanodized ones.

Backlash-versus-time curves

For an evaluation of the wear rates of some of the significant meshes, see charts A to D:

Aluminum, steel, anodized aluminum—Chart A. Only four meshes completed the 2000-hr test (Mesh 3, 4, 7, and 8). These were combinations of stainless-steel pinions versus anodized and unanodized aluminum gears. The other four meshes were discontinued during the test because of excessive wear. Mesh 5 and 6 did not show a definite increase in backlash until the anodized finish began to break off (at 500 hr). The finish wore entirely off the face of the gears at 750 hr. From this point on, the rate of wear was about the same as for Mesh 1 and 2.

Mesh 7 and 8 produced only about 0.001-in. backlash throughout the 2000 hours.

Rulon, nylon, anodized aluminum—Chart B. Mesh 1 and 2 began to wear rapidly from the beginning and were removed after 700 hours because of extreme tooth wear. Wear products in the form of a very fine black powder were deposited profusely. Mesh 3 and 4 continued without interruption for the required 2000 hours, with an increase in backlash of less than 0.0001 in. No wear products were seen.

After testing, all gears were cleaned and examined. Most wear on Mesh 1 and 2 occurred on the anodized aluminum gears rather than the Rulon pinions. The Rulon pinions were loaded with aluminum oxide particles, which undoubtedly caused wear on their mating gears.

Nylasint, anodized aluminum—Chart C. All meshes of various Nylasint-material pinions meshed with anodized-aluminum gears completed the 2000-hr life test without significant increase in backlash.

A slight amount of wear products was noticed under the meshes (not shown) whose pinions were hobbed from the Nylasint material having the graphite filler.

Sinite, anodized aluminum, steel—Chart D. These curves show clearly the slight wear suffered by the two material combinations composed of Sinite D-108, anodized aluminum and stainless steel. There was no measurable increase in backlash on one test involving anodized aluminum. In fact, the final backlash figure was less than the initial backlash reading. No wear products were in evidence beneath the test meshes.

For REPRINT of above article, just check 588 on one of the Reader Service cards found in this issue.

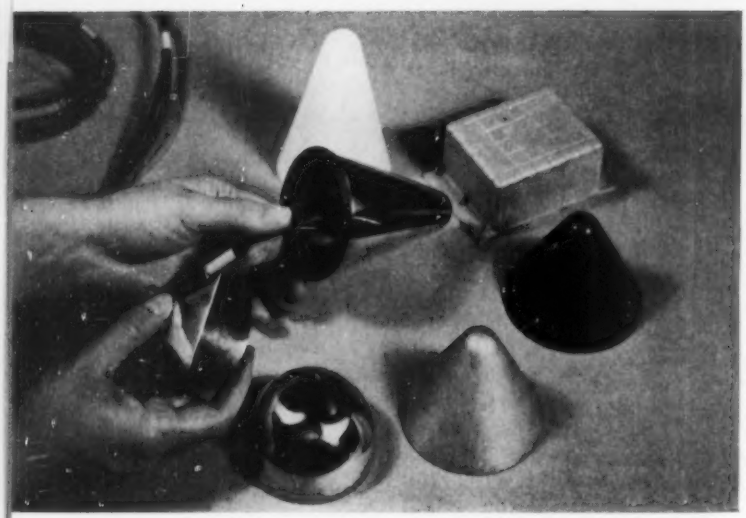
EDITOR'S NOTE: For information on predicting wear of other gear materials, and how to lengthen wear life see:

How to Predict Wear-life of Rolling Surfaces, May 9 '60, p 44—Gives wear factors for various material and hardness combinations, and equations for computing life expectancy of gears, cams, bearings, pin joints.

Choosing a Metal to Resist Wear, Aug 22 '60, p 43—Here's a guide to properties which resist wear best.

New Coefficients Predict Wear of Metal Parts, June 23 '58, p 71—Analysis of four types of wear; simple formulas for predicting wear of sliding systems.

—Nicholas Chironis



7-STEP TECHNIQUE
developed for model nosecones, makes metal and plastic parts with walls down to 0.010 in. thick quickly and economically.

THERMOFORMING + INVESTMENT PROCESS = ULTRATHIN-WALL CASTINGS

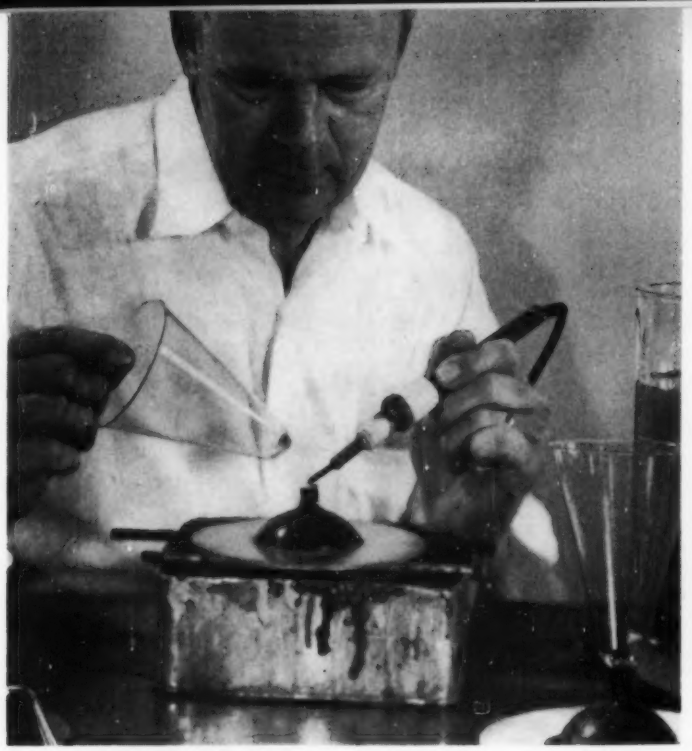
A E CLARKE JR, *Ames Research Center*
National Aeronautics and Space Administration
Moffett Field, Calif

Take a sheet of plastic, form it over a mandrel, invest the resulting plastic shape with ceramic slurry, and oven-fire it—you now have a low-cost mold for centrifugally casting ultrathin metal and plastic shapes. These are the basics of a new technique devised at Ames Research Center to produce thin-wall nosecone models for repetitive testing in the high-speed wind tunnel at Moffett Field, Calif.

Because of excessive heating in these simulated reentry tests (see cover and p 3), model nosecones can seldom be reused. Further, many materials have to be checked—thus a simple, quick way of making many models is a must. Processes such as electroforming, machining and stamping are expensive and time-consuming. The 7-step technique illustrated here—a combination of thermoforming and investment casting—has proved to be a sure method that does not require expensive tooling and avoids production delay. The process can be applied to any thin-wall part for which it is possible to thermoform a pattern.

The major items of equipment needed for this process—thermoforming machine, programed oven, vacuum system, crucibles, and centrifuge—can be purchased commercially for a total expenditure of about $5000. The thermoforming machine illustrated here, however, is a homemade device.

1 . . MAKE THE THIN-WALL PLASTIC PATTERN by thermoforming cellulose acetate butyrate (CAB) sheet over a male mold. Heating the stretched sheet with a coiled heating element (at operator's left hand) softens the thermoplastic sheet and helps it drape uniformly over the mold. Vacuum applied to underside of the film fits it snugly to the mold. Plastic will thin 20 to 30%, depending on depth of forming; but this can be allowed for in selection of sheet thickness. Styrene or butacrylic sheet—each has good investment burn-out characteristics—can be used, though CAB sheet is preferred because of its uniform thickness. Male molds of metal, wood, or plastic will simplify manufacture. Mold-release is not necessary—a blast of air will free the formed plastic pattern.

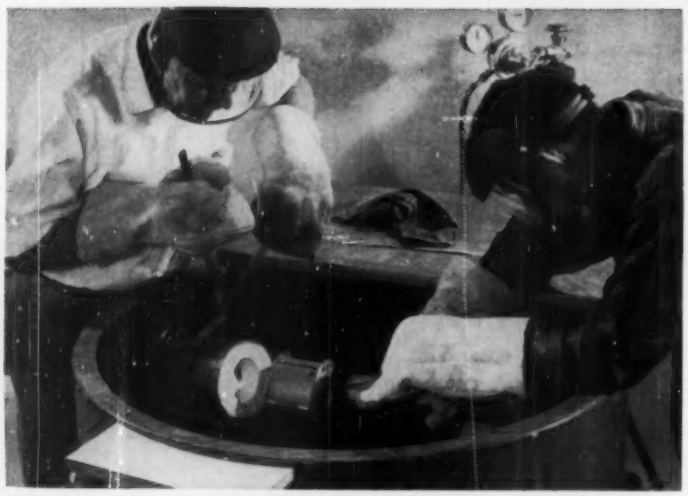


2 . . ADD A WAX SPRUE PATTERN to the plastic pattern by softening the wax slightly with a soldering iron. Add only enough heat to make the wax tacky; excessive heat will distort the thermoformed plastic pattern. Gates and risers are seldom needed in investment casting, because the molds are porous enough to allow the molten metal to flow easily into the cavity. Bosses and stiffening webs can be added at this point, if desired, either with investment wax or with pieces of CAB plastic bonded in place with a solvent like acetone. Additions of this sort that have intricate shape can be machined from acrylic blocks or bar stock, or cast to shape using acrylic casting resins. Molds can be made from fluid silicone rubber that vulcanizes at room temperature *(PE—Dec 26 '60, p 50)*. Plastic pattern at author's left hand has already been joined to its sprue.

3 . . CLEAN THE PLASTIC PART OF THE PATTERN by dipping it in a detergent solution to break the surface tension of the plastic. This acts as a "de-bubbler" and helps keep the pattern free of air when the investment slurry is poured. If this is not done, tiny globules of metal will appear on the surface of the cast metal part. Any nonclinging household liquid detergent diluted with water can be employed for this cleaning step. Shown at right, below author's hand, are: another plastic pattern, and a finished investment flask. Note that both patterns are mounted on base plates at this stage.

4 . . MAKE THE INVESTMENT MOLD in the normal manner. Place the pattern into a cylindrical flask and surround it with an investment slurry. Simplest method is to place the flask containing the coated pattern in a vacuum chamber and drive the slurry into the flask by drawing a vacuum of 26 to 28 in. Hg. This ensures that all air is removed, especially if the flask is rocked slightly to free air bubbles. Be sure this action does not break the plastic pattern loose from its wax base. In the photo, note the spring-mounted table for this purpose. Simplest flasks are built with perforated stainless sheet lined with asbestos paper—a combination that helps the cavity breathe during casting. Here are some suggested slurry materials: Kerr Co's Cristobalite, K-90, or Duracast 20; or Ransom and Randolph Co's No. 417 or No. 511. For ferrous metals, a dip coat is sometimes used before investing the pattern. For this, use Kerr's Ferromold, or R & R's No. 711.

5 . . FIRE THE INVESTMENT MOLD in a well-ventilated furnace to ensure thorough burn-out of the plastic-wax pattern. For uniform burn-out, program the firing operation over about 16 hours, starting from 200 F and rising to 1300 F, for molds for casting aluminum or bronze parts; to 1800 F, for molds taking stainless steels. Be sure that all pattern residue and ash are removed to ensure clean castings.



6 . . CAST THE METAL PART into the hot ceramic mold, using centrifugal force to drive the molten metal into very thin sections before it can chill. In this way castings as thin as 0.010 to 0.020 in. can be made. In the photo at left, the mold is being positioned next to the crucible in the centrifuge. The mold should be held in the furnace until the metal is up to casting temperature. The holding temperature depends on the metal to be cast: 800 F for aluminum, 1000 F for silicon bronze and about 1300 F for stainless steel. This can be made part of the oven-firing. Thin parts made from thermosetting casting resins are also made easily by centrifugal casting *(PE—May 23 '60, p 45)*.

7 . . BREAK THE INVESTMENT AWAY from the casting after cooling the mold and knocking off the stainless supporting flask. Even though the casting is thin, the investment completely surrounds it, so that hammer and chisel can be applied without damaging the part. Note smooth glossy as-cast surface of the part (in last photo). Slug of metal at lower right represents sprue opening, and must be trimmed away. Casting is then polished and prepared for use.

EDITOR'S NOTE: Other recent articles on methods of producing short-run cast parts with minimum expense include:

Silicone Rubber Molds for Short-run Castings, Dec 26 '60, p 50—Article shows how room-temperature-vulcanizing silicone rubbers can be quickly turned into molds for casting metals or plastics.

Epoxy Parts Cast by Centrifugal Force, May 23 '60, p 45—How to get precision plastic parts in quantities that do not justify high tooling cost of injection molding.

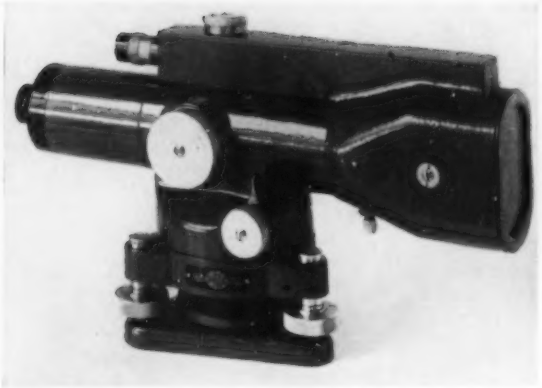
Cheaper Prototypes from One-shot Investment Castings, Jan 4 '60, p 55—Plaster molds made by "lost wax" method and low-melting-point alloys provide a cheap, quick way to visualize a cast part before committing it to production.

Speed Your New Product with Cast Epoxy Models, Dec 21 '59, p 60—Casting technique allows simultaneous appraisal of many designs by key departments—engineering, production, and sales.

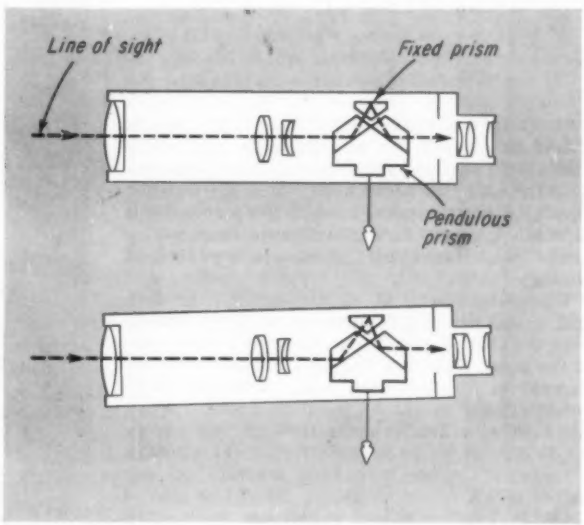
—Ford Park

These Swinging Prisms Have to Stay Level

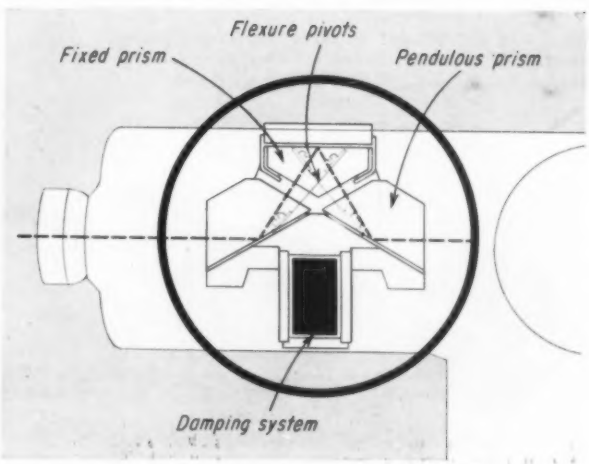
In this optical device, pendulous prisms on flexure pivots level line of sight automatically. Self-correction feature speeds setup and work.



LEVEL has a telescope (32X) which rotates in a horizontal plane. An optical reading micrometer is fitted to the objective and a three-screw leveling base with a circular bubble-level is provided. Eyepiece of the optical micrometer is above the telescope eyepiece. The micrometer consists of a pivoted, parallel-sided glass refractor block with attached scale. This enables line of sight to be raised or lowered by a known amount.



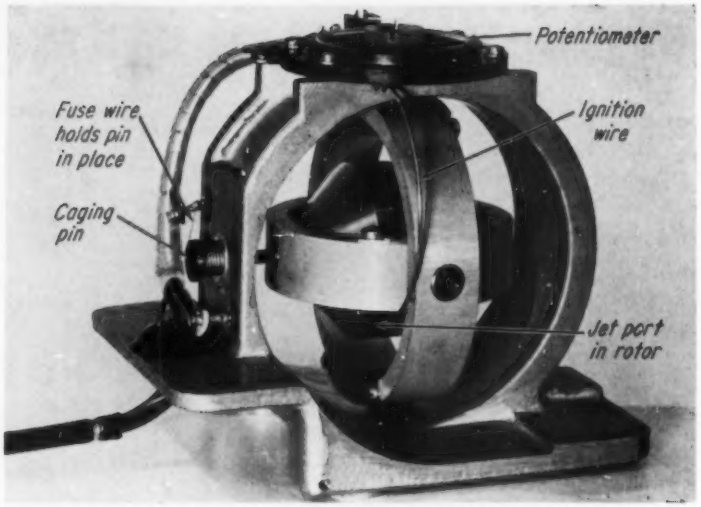
OPTICAL STABILIZER system, using three prisms—two pivoted and one fixed—maintains a level line of sight when the telescope is tilted. The two suspended prisms are supported by four metallic tapes forming a cross-spring flexure pivot. Frictionless suspension has a repeatability of less than 1 sec of arc. The fixed reflector is a roof prism that produces an erect image. The suspended double prisms change their angular relation to the optical axis at the same rate as the telescope is tilted, maintaining a horizontal line of sight. Oscillation of the pendulum is damped by an air dashpot which restricts total swing of the flexure pivot to $\pm$ 20 min. Damping system also supports weight of the suspended prisms during transport.

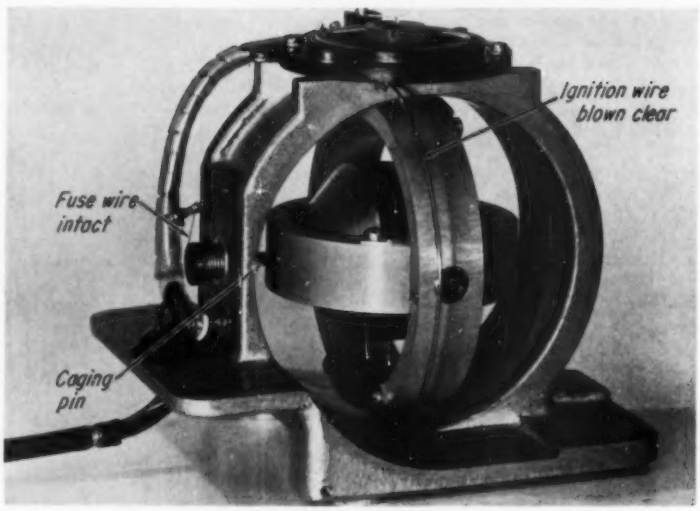


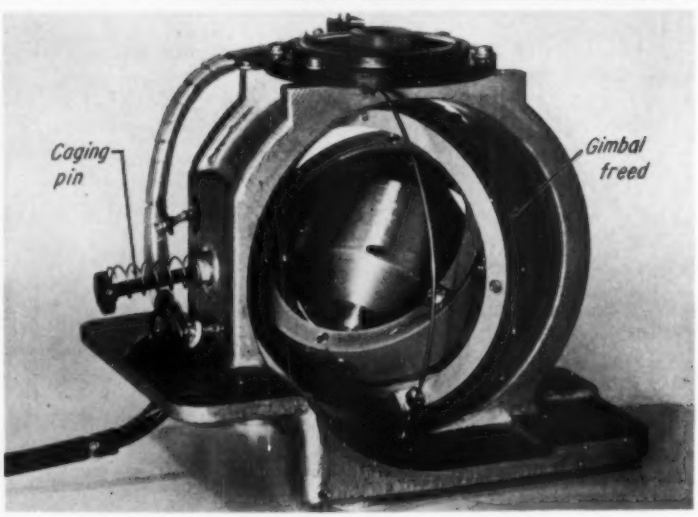
PS . . . Optical level is used in engineering measurements such as leveling of foundation pads for heavy equipment, machine-tool beds and aircraft fixtures. All measurements are made from a datum plane represented by the horizontal line of sight. Vertical displacements within a range of 0.5 in. can be read directly to 0.001 in. in the optical micrometer. Autoset level is produced by Hilger & Watts Ltd, London, Eng.

Timed Blast Powers Pyro Gyro

Rotor reaches speed in 100 milliseconds for short-duration attitude control and data collection; has 1/4 the number of parts required for equivalent spring-driven gyro.



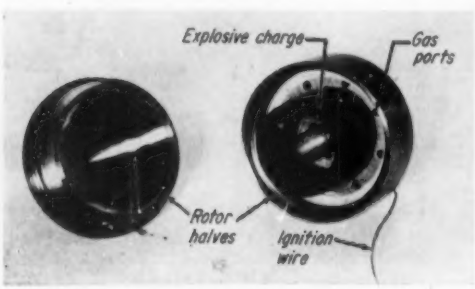




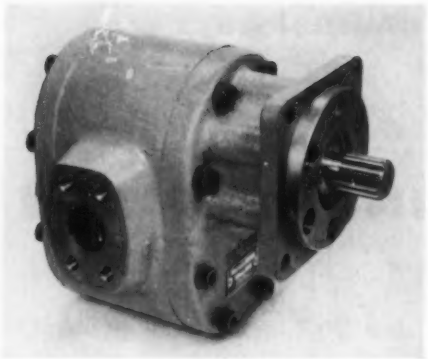
CAGED GYRO, ready to fire, has both gimbals locked in position by the spring-loaded caging pin, which, in turn, is held by fine fuse wire running through slot in its head. Ignition wire for explosive charge passes through jet port in rotor to reach igniter. Potentiometer is mounted on top of frame, input shaft is connected to vertical gimbal.

When the electrical circuit common to both igniter and caging-pin fuse wire is closed, igniter fires the charge, and the ignition wire pulls clear of the port. The time required for the electrical current to burn out the fuse (0.020 sec max) permits rotor to reach operating speed. When the fuse wire finally burns through, the caging pin is ejected by its spring, freeing the gimbals.

Rotor of pyrotechnic gyro consists of two halves which screw together. Explosive charge inside is doughnut-shape to promote progressive burning. Burning gases escape through tangential jets drilled through the circumference to turn the rotor. Principal applications are stabilization of short-range missiles throughout flight or stabilizing longer range missiles during early stages, telemetering, and torpedo guidance.

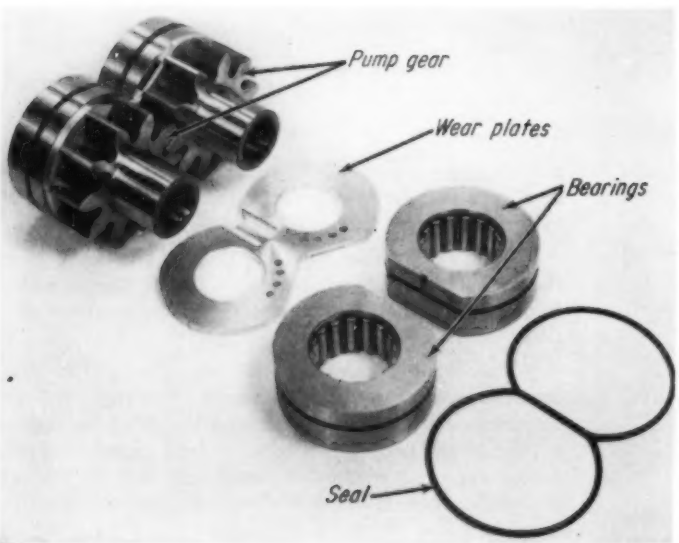


PS . . . Free gyro, mounted in double gimbal rings, can turn in any direction or attitude. It measures deflection, in terms of total movement from the original position, by a potentiometer mounted on the supporting frame. Rotor develops an angular momentum of 3.4 x 105 gm cm²/sec at 36,000 rpm. Pyrotechnic Free Gyro Model 34110 is produced by Gianni Controls Corp, Pasadena, Calif.



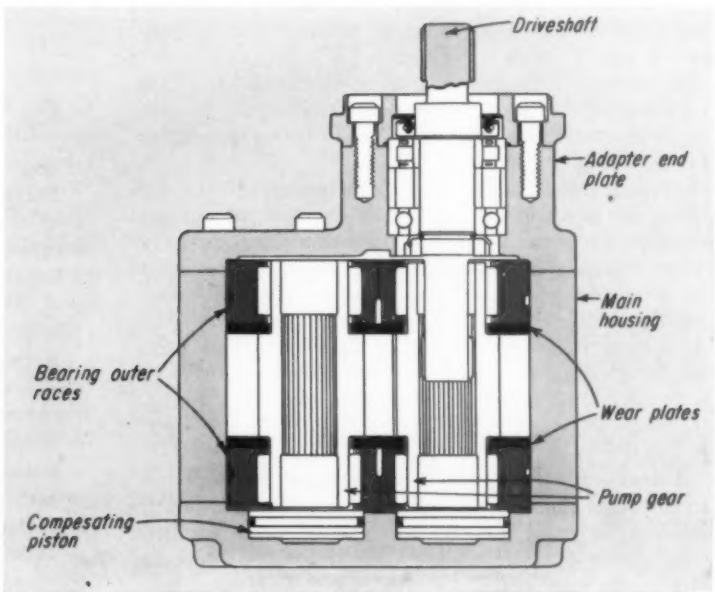
Packaged Pump Bearings Assemble Faster

Outer races fit into center section, not into end plates where they would require close alignment. The larger bearing rollers raise speed and load limits but not the pump size.



BEARING RACES are key to simplified gearpump design. They are designed to fit into the center section of the pump, not the ends. Bearings, wear plates, pump gears and seals are assembled into a single package and slipped into a matching opening in the main pump housing. Opening in main housing matches OD of bearings; this eliminates need for alignment of bearings in end plates. Oversize outer races permit use of larger rollers; mating flat sections determine distance between gear centers. Diameter of the roller bearings is larger than usual. This reduces their rotating speed and allows higher bearing loads. Holes and channels in wear plates provide lubrication for bearings. A seal in figure-8 shape replaces two O-rings previously used.

Simple housing covers are primarily to close the pump housing. Adapter end-plate contains bearings which support the separate driveshaft. Splined driveshaft slips into the matching internally splined pump gear, further simplifying alignment.



PS . . . End covers of pump are merely closures and have no effect upon pump gear alignment. Covers need no dowels; only alignment requirements are at the adapter end where splined driveshaft slips into hollow gear. Hydraulic gearpump is available in three sizes (40, 60, 80 gpm) at 1200 rpm. All three sizes are rated at 2500 psi at 2500 rpm. Model 2500 pump is produced by Parker-Hannifin Corp, Cleveland.

when fluid flow must be varied in unusual ways . . .

THESE VALVES FOR NONLINEAR FLOW

Our Feb 6 issue described valves with flows that varied in almost direct proportion to stem or plunger movement. Now here are 11 special valves that vary flow in any nonlinear manner desired

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When liquid or gas flow must vary in some unusual way, such as in a cylinder application where piston speed varies during the stroke, a nonlinear flow valve may be the answer. A nonlinear valve is one in which flow is not directly proportional to the position of the valve stem or spool. Flow is then a "nonlinear" function of valve movement.

It may seem easier to get nonlinearity by hooking a special external mechanism onto an ordinary valve. Then a simple movement at the input of the mechanism will cause the valve stem to follow the desired pattern of output movement. Sketches on the next page show how fundamentally simple this can be.

But such external mechanisms–with their cams, linkages or noncircular gears that generate the nonlinear motion–are likely to be bulky and expensive, and simplicity is soon lost because of mounting problems and maintenance.

More often, a better way to get nonlinear flow is with a nonlinear valve that has special ports or plungers. Mounting requirements are then ordinary, and the valve actuator can be a simple shaft or pushrod.

Typical linear valves with function-generating cams added are shown in the sketches on the next page. Both examples are of needle valves–one with a rotary cam, the other with an axial (back-and-forth) cam. A spring holds the needle firmly against the cam surface, but rapid movement and excessive friction will sometimes prevent the valve from following the cam. However, special cams can be designed to contact the valve stem positively in both directions, thus eliminating the need for a spring.

NONLINEAR VALVES

A nonlinear valve eliminates the external hardware and accomplishes the function with internal contours. Each nonlinear valve in the sketches is based on a standard valve type–needle, sleeve, plate, spool–contoured internally to pass the scheduled flow. The first five are essentially axial-motion valves; the remainder are rotary types. However, many of the principles of one type can be applied to the other.

Needle valve is the type most common. Instead of the ordinary plain taper, there is a nonuniform variation in diameter that produces a specific flow-vs-position function. Motion is axial.

Wedge-shape needle valve is a variation on the contoured needle valve. Flow is through the segment-shape area formed by slicing a contoured wedge off the tip of a cylindrical "needle." For each axial position of the needle, there is a different segment area, and the contour of the slice determines flow-vs-position characteristics.

Sleeve valves may have a nonuniform slot in the sleeve that uncovers a varying area depending on axial position. Or a drilled sleeve will vary the flow in a manner determiner by hole sizes and their relative axial position in the sleeve.

Plate valve has a contoured edge that passes over a circular port. The area uncovered is a function of the shape of the sliding valveplate called the "cam."

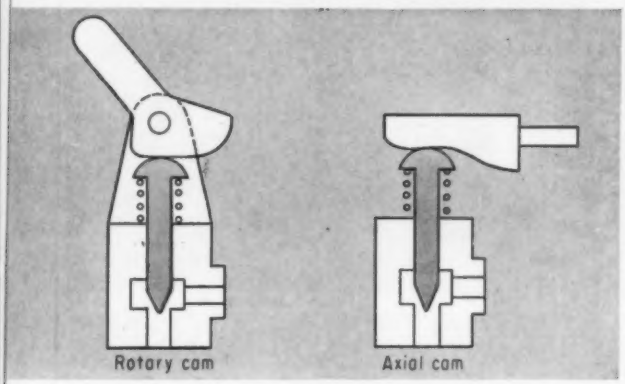
Rotary contoured-end valve does not differ in principle from the slotted-sleeve axial valve. Each depends on an irregular slot cut in the sleeve or drilled end to vary flow nonuniformly with position. In the rotary version, the port can be a hole or an axial slot in the valve bore. In the axial type, the port is annular.

Rotary spool valve changes flow by varying the uncovered area of the hole controlled by the contoured land. Functionally it is a duplicate of the rotary contoured-end valve.

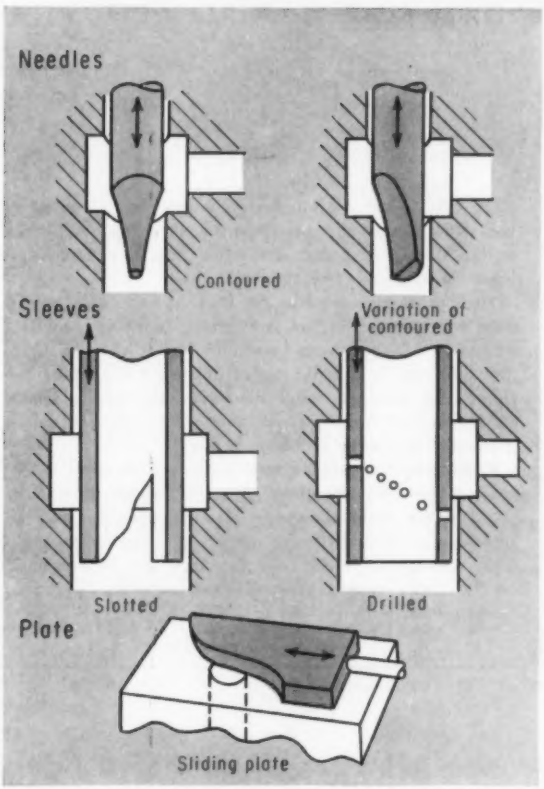
Rotary drilled-face valve has a pattern of axial holes in the stationary face of the valve. The rotary part is a semicircular plate that slides across the holes and uncovers more and more of them as its stem is rotated.

Contoured-cam-plate valve has a single drilled hole in

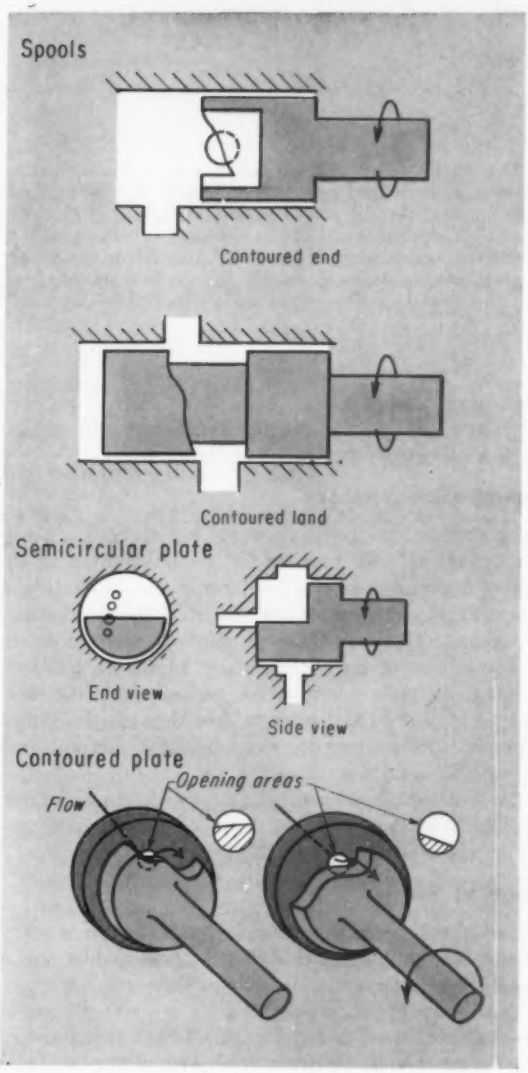
Linear Valve, Variably Actuated



Nonlinear Valves, Axial



Nonlinear Valves, Rotary



the stationary plate. Rotating cam plate determines flow by uncovering varying portions of the port. Shape of uncovered opening in each position is approximately a segment of a circle whose diameter is that of the hole. If valve-plate contour is abrupt or ragged, the flow area is not quite a segment, but the deviation is small.

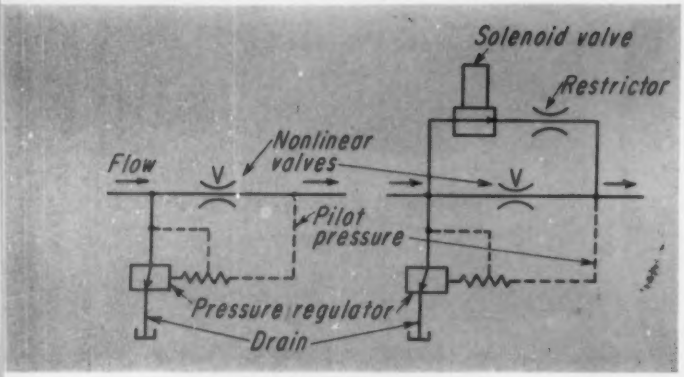
Flow change vs angular movement of the valve depends on cam contour and hole location; by increasing diameter of the rotating valve plate and locating the hole farther out, the effective movement for each degree of valve rotation is increased. Photo on next page shows actual example of contoured-cam valve.

SPECIFYING VALVE PERFORMANCE

Whether you are designing your own nonlinear valve or writing specifications for one, flow must be stated for each position of the valve plate or plunger. Knowing the conditions, the valve designer can calculate the proper shape of the port or movable valve plate.

Affecting performance are supply pressure, load restriction (output), abruptness of valve contour, leakage, fluid characteristics, dirt, discharge coefficient, and other parameters common to any fluid circuit.

A pressure regulator across the valve will eliminate effects of supply pressure and load restriction; it can hold



TYPICAL FLOW CIRCUIT on left has a nonlinear valve with a regulator to hold pressure constant. But for abrupt changes in flow beyond ability of any steep-rise contoured valve, circuit at right has added a solenoid valve controlled by limit switches to help adjust flow. Restrictor can be of fixed size, adjustable, or just left out for certain applications. Regulator can be made automatically adjustable.

pressure drop constant for entire flow range. If flow change must be unusually abrupt, or if leakage will unduly affect flow accuracy, other steps can be taken.

For abrupt flow changes

Valve contour can be fairly steep, but there is a limit to the change in flow possible for a small movement of the valve if pressure drop is held constant. No internal or external cam arrangement can accurately handle extreme flow changes. However, there are alternate ways to do it. One way is to put an automatically adjustable pressure regulator across the nonlinear valve; an increase in the controlled pressure drop will increase flow through the valve. The proper valve contour can be designed if the pressure-drop variation is known accurately.

For very abrupt flow changes, a flow path can be added in parallel with the nonlinear valve. The schematic on this page shows how.

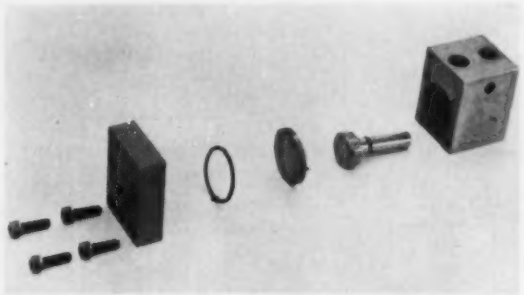
Leakage vs friction

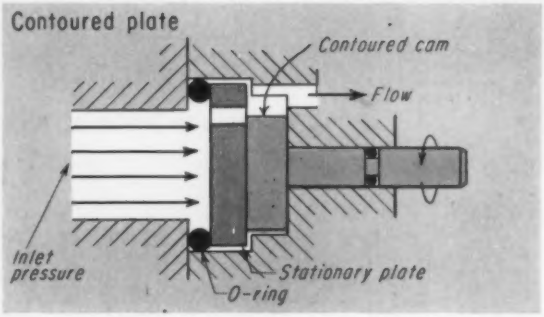
A leaktight valve needs zero clearances between moving parts and will usually have higher friction than a valve designed for easier movement. Conversely, a low-friction valve usually has greater leakage.

For example, spool and sleeve valves have slight or no physical contact, and therefore have low friction. However, complete shutoff is impossible, although in many cases the leakage flow is negligible compared with the metered flow.

Ordinary plate valves can eliminate leakage by forcing the rotary valve element against the fixed valve plate with a stiff spring. This spring load must be sufficient to withstand the greatest expected axial forces (fluid or mechanical) or the valve will separate from its mating face. High friction is thus "built in."

A variation on the rotary-plate valve, shown in the photo, top of this page, eliminates the valve spring entirely by using fluid pressure to hold the mating parts in contact. Friction is lower, particularly at low pressures, yet leakage is not increased.





FUEL VALVE for a small aircraft engine has a contoured cam that rotates and gradually uncovers the small hole in the stationary plate, passing a flow that is a nonlinear function of valve rotation.

Fluid pressure instead of the usual spring holds mating parts together, so friction is reduced, particularly at low pressures. O-ring helps maintain compressive loading, and also acts as a seal. Radial alignment is held by the close-fitting stem—its small diameter helps nullify effects of temperature variations, simplifies machining, and makes it possible to use an aluminum housing.

Flow ranges available are 3-60, 4.5-90, and 6-120 cu in. min with differential pressures varied from 2-15 psi. Where more than one flow schedule is desired, substitute a different valve plate. Or where less than 180° rotation is needed, two functions can be machined on the same rotating plate. Normal accuracy is ±5%. Temperature range is —65 to 250 F.

For REPRINT of above article, just check 587 on one of the Reader Service cards bound in this issue.

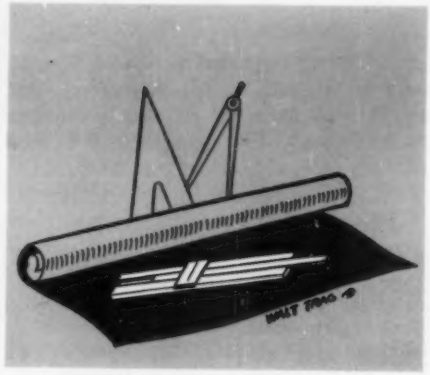
EDITOR'S NOTE: For valves that must have linear response, see this previous article in PE:

How Linear are Flow-control Valves, Feb 6 '61, p 47—Has sketches of ordinary and special direct-response valves, and gives flow equations and curves.

A survey of all types of flow control valves, with cross-section views and important characteristics described, is found in these previous 5 articles:

Relief Valves, Dec '56, p 174; **Pressure-control Valves,** Jan '57, p 196; **Flow-control Valves,** Mar '57, p 144; **Directional Valves,** May '57, p 167; and **Valve Circuits,** July '57, p 197. These articles have also been incorporated in a book: *Fluid-power Controls,* Pippenger and Koff, available from McGraw-Hill Book Co.

—F D Yeaple



SLIDERULE SHORTCUTS

for frequently needed data

Because of chance relationships between scales, your sliderule can often serve as a reference table. Here are some examples, and hints for finding tabular aids on your own. Author also tells how to make a special-purpose rule for a recurring equation.

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University of Alabama

Along with the variety of intentional features designed into the modern sliderule are some unintentional ones that can be used to your advantage. The fortuitous location of log-log scales and inverse scale, for example, may allow you to read values of some irregular curves directly from your rule. Or data normally found in reference tables, which cannot be computed by simple equation, may be lurking on your rule—it remains only for you to find the proper combination of scales. The sample shortcuts given here were "discovered," not logically derived, but others can be "discovered" the same way.

To be sure, such relationships are valuable only for frequently used data. In general, you must remember one critical pair of values so that the rule can be set to read others. Accuracy is not as good as in the actual tables but many of these approximations are surprisingly close. For quick answers—the sliderule's chief attraction—the data are usually adequate. Though the range of values that can be read is limited, most of the following examples cover the commonly needed values of the variables.

Wire and sheetmetal gages

The relationship between Brown & Sharpe gage number and thickness of nonferrous sheetmetals (also AWG gage numbers for wire diameters) is a uniform geometric progression—the actual relationship is $T = (0.325)(0.890{,}53)^{\text{gage no.}}$ You can find these thicknesses directly with the L scale and the C scale. Align 70 on the D with 72 on the C. Now read thickness on C opposite a number that represents gage number on L. Gage number 0 is represented by 0.5 on the L and every 0.05 points on the L represents a difference of one gage number. Thus, 0.4 on the L is gage 2 and thickness (0.258) is found on C. And 0.6 on the L (gage 000) is 0.409 on the C. Gage numbers larger than 10 (which is represented by 0 on L) are found by continuing to mentally recalibrate the L scale from the right. For example, gage 16 is 0.7 on the L and thickness is 0.052 on the C. Accuracy is within about 2% for the full range of gage numbers (0000 to 40).

If your sliderule does not have an L scale, you can substitute an ordinary 12-in. ruler. Remove the slide and align the 5-in. mark on the ruler with 0.331 on C. Answers will be slightly different (accuracy is poorer) because ruler is slightly longer than L scale. Here are some typical values compared with table values as read with the L scale.

Gage No.	0000	0	8	16	24	32	40
Sliderule	0.459	0.325	0.130	0.052	0.0205	0.0081	0.0032
Table	0.460	0.325	0.128	0.051	0.0201	0.0080	0.0031
% error	0.2	0	1.5	2.0	2.0	1.2	3.0

Viscosity of water

Because there is a direct logarithmic relation between the viscosity of water and its temperature, the L and D scales

text continued, page 53

REPRINTED—Circle 589, inside back cover

Cardboard rule solves 4-variable equations

■ Here's another timesaver for data you need frequently. Rather than solve and re-solve the same equation on your multipurpose sliderule—with time-wasting resettings and the risk of misplacing the decimal point in the answer—make a special-purpose paperboard sliderule.

It is easy to make such a sliderule that will handle up to 4 variables. Only four construction steps are needed to give a rule that will solve any equation of the form

$$k\,(a^m\,b^n\,c^o\,d^p) = 0$$

where a, b, c, and d are variables; m, n, o, p are powers, either positive or negative; k is a constant. Proper layout of the rule depends on only three factors: length of scales, direction of calibration, and lateral placement of the scales on frame and slide members.

Here are the four steps:

1 . . . Set equation equal to zero and rewrite all terms as sum and difference of logarithms.

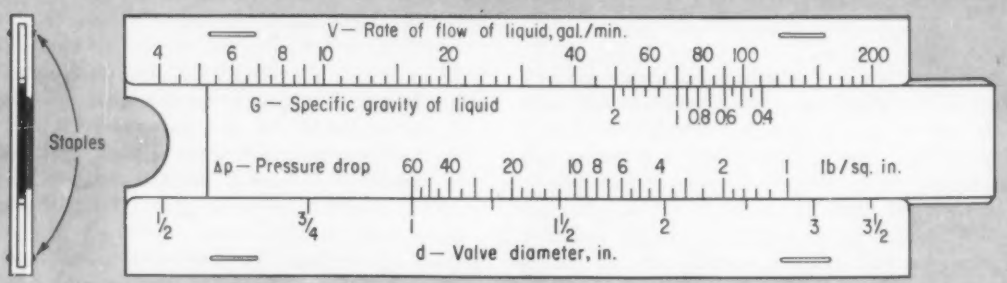
2 . . . Choose a range for each variable and a convenient length, M, for a single cycle of a logarithmic scale. Compute length, L, of scale for each unknown from equation

$$L = M\,p \log \frac{x_2}{x_1}$$

where X_2 is upper limit of unknown, X_1 is lower limit and p is any power of the unknown. It is best to choose a cycle length M equal to some convenient log scale—the scales of your sliderule or the graduation on a piece of log paper are most common. Squared unknowns will have cycle length twice as long; square roots, half as long. For odd powers, proportion the scale graphically from another log scale. The same value for M will be used for computing all scales on the sliderule.

3 . . . Make a rough sketch of the scales as they will appear on the slide and the frame members. Direction of scale calibration will depend on the sign of the function as it appears in the logarithmic form of the equation. If two functions have the same sign and appear on the same member or on adjacent scales of different members, they are calibrated in opposite directions. If the signs are different, they are calibrated in the same direction. If these rules are satisfied, it makes no difference on which of the four scales the function appears.

4 . . . Lay out the scales on a paperboard rule cut and bent from a file folder. Or, for a more durable rule, mount or etch the scales on wooden or plastic sliderule blanks. Solve the equation for any set of unknowns and position the scales laterally so that they give the proper solution. This will automatically take care of any constants of multiplication. It is best, of course, to arrange the scales so that they will be centered as nearly as possible on the rule. ■


V— Rate of flow of liquid, gal./min.
4 6 8 10 20 40 60 80 100 200
G — Specific gravity of liquid
2 1 0.8 0.6 0.4
Staples
Δp — Pressure drop
60 40 20 10 8 6 4 2 1 lb/sq. in.
1/2 3/4 1 1 1/2 2 3 3 1/2
d — Valve diameter, in.

FLOW OF LIQUID through parabolic plug valves is shown by one setting on this rule. The equation it solves is

$$V = 9\,d^2 \sqrt{\frac{\Delta p}{G}}$$

where V is rate of flow (4 to 200 gal./min.), d is valve diameter (½ to 3½ in.), G is specific gravity of liquid (0.4 to 2.0), and Δp is pressure drop (1 to 60 lb/sq in.).

In making the rule, first step is to rewrite the equation in logarithmic form:

2 log d − log V + 0.5 log Δp − 0.5 log G + log 9 = 0. Choosing a cycle length of 12.5 cm. (the length of one cycle on the B scale of a standard 10-in. sliderule) the length of each scale becomes:

$$L_V = (12.5) \log 200/4 = 21.24 \text{ cm}$$
$$L_d = (12.5)\,(2) \log 3.5/0.5 = 21.13 \text{ cm}$$
$$L_{\Delta p} = (12.5)\,(0.5) \log 60/1 = 11.11 \text{ cm}$$
$$L_G = (12.5)\,(0.5) \log 2/0.4 = 4.37 \text{ cm}$$

The placement of scales is arbitrary. In this case, it was decided to place V and d scales on the frame with V adjacent to G and d adjacent to Δp. Therefore, if d increases to right, V will also increase to right because they have different signs in logarithmic form of equation. Δp will increase to left because it has same sign as d, and G will increase to left because it has same sign as V. As a check, notice that G and Δp increase in same direction as required by their opposite sign.

The V and d scales were calibrated from the B and C scales, respectively, of a standard sliderule and the G and Δp scales from the B scale of a 5-in. rule. The V and d scales were centered on the frame and the G and Δp positioned laterally to satisfy the equation.

show viscosities between 10 and 60 deg C without any settings or manipulation. But you have to remember that each 10 degrees is separated by 0.15 points on the *L* scale: 1.0 corresponds to 10 C, 0.85 corresponds to 20 C, 0.70 corresponds to 30 C, and so on. Read the number on the *D* opposite the appropriate factor on the *L* and add 0.300 for viscosity in centipoises. Interpolate for intermediate temperatures. The values are accurate within 2%. The following table compares sliderule viscosities with actual viscosities.

Temp, °C	10	20	30	40	50	60
Sliderule	1.300	1.008	0.801	0.655	0.551	0.478
Table	1.308	1.005	0.801	0.656	0.549	0.469
% error	0.6	0.3	0	0.2	0.4	2.0

Water in saturated air

The specific humidity (lb water per lb dry air) of saturated air can be read directly from square root and log-log scales. To read these values, you must remember that saturated air at 90 F contains 0.0310 lb water (approx.) per lb dry air. Set 90 on *B* scale opposite 310 (0.0310×10^4) on *LL*3 scale. Read other specific humidities from *LL*3 and move decimal point 4 places to left. The agreement with actual values is within 2% in the range between 60 and 100 F. The table below compares sliderule values of specific humidity with values from a psychometric chart.

Temp, °F	60	70	80	90	100
Sliderule	0.0108	0.0158	0.0224	0.0310	0.0423
Chart	0.0110	0.0157	0.0222	0.0309	0.0428
% error	1.8	0.6	0.9	0.3	0.7

Pipe friction factor

The constant in the equation for computing frictional pressure drop usually must be read from a chart because it is a function of Reynolds number. But it can also be read from the *LL* and *CI* scales of the sliderule. A common pressure-drop equation (there are several variations) containing the friction factor *f* is

$$\Delta P_f = \frac{2 f \mu L \rho}{g D}$$

where ΔP_f is frictional pressure drop, μ is viscosity in lb/ft-sec, ρ is density in lb-mass/ft^3, g is the gravitational constant and *D* is diameter of pipe *L* ft long. To find *f*, set 4.21 on *CI* scale opposite 10,000 on *LL*3. In this position, the numbers on *CI* are $f \times 10^{-3}$ and the numbers on *LL*3 are (Reynolds number) $\times 10^{-3}$. For Reynolds number 100,000, slide hairline over 1000 on *LL*3 and read friction factor 0.0056 on *CI*. Agreement with actual values is good (see table, next column) and sufficiently accurate, because friction factors are only valid to about ± 10%. Friction factors for other similar equations can also be read using another alignment of the same two scales.

Reynolds No.	5000	10,000	100,000	500,000	1,000,000
Sliderule	0.0099	0.0084	0.0056	0.0045	0.0042
Chart	0.0103	0.0086	0.0054	0.0045	0.0043
% error	3.9	2.3	3.7	0	2.3

Other relationships

To illustrate how your sliderule can pinch-hit for other tables, consider these two examples. (1) The viscosity of 100-psia steam at various temperatures can be found from *B* and *D* scales. Set 850 F on *B* opposite 0.026 centipoises on *D*. Viscosities on *D* between 500 F (μ = 0.020 centipoises) and 850 F are accurate within 1%. (2) Specific volume of 200-F "Freon 11" at various pressures is an inverse relationship. Set 1 psi on *CI* over 50 cu ft/lb on *D*. Accuracy is within 2% (1 to 10 psi).

Finding the proper accidental relationship is not always easy. You may have to tinker with several possibilities before you get the right combination. The scales used may have nothing to do with the relation between values. You can even turn the slide around, or upside down.

For example, here is a really bizarre relationship. The number of 4-ft logs in a cord of wood (by US Standard: a pile 8 ft long, 4 ft high,, 4 ft wide) depends, of course, on average diameter of the logs. Remove the slide and replace it so that the *T* scale is upside down and opposite the *A* scale. Remembering that there are fifty 9-in.-dia logs in a cord, set 5 on the A (left end) opposite 9 degrees on the inverted *T* scale. You can now find the number of logs in a cord by setting average diameter under hairline on *T* scale (reading degrees as inches) and reading number of logs × 10 under hairline on *A*. The method is accurate within about 3% (logs 8 to 12 in. dia).

For REPRINT of above article, just check 589 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: For more sliderule tricks and mathematical shortcuts, see:

Get More From Your Sliderule, Nov 7 '60, p 73—13 examples show how to use all the built-in features on your rule.

Better Way to Place Sliderule Decimal Point, Oct 10 '60, p 65—"Supes" and "subs" eliminate serious errors, reduce computation time.

Design Nomographs the Easier Way, Oct 10 '60, p 66—Once the equation is in the form of a determinant, the nomograph is done . . . nearly. The layout is easy, requires no guesswork.

Logarithmic Diagrams Solve Your Equations, Nov 23 '59, p 62—Diagrams on log-log paper make a kind of alignment chart that is easier to lay out than the familiar nomogram.

Rectangular Nomographs, Mar '56, p 192—A quick, graphical way to solve equations with four variables.

Three-dimensional Nomograms, Aug '55, p 186—A concise, informative method for solving higher-order equations.

—Charles J Lynch

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8... FEEDER MECHANISMS – angular motions
9... FEEDER MECHANISMS – curvilinear motions

9...FEEDER MECHANISMS— curvilinear motions

Four-bar linkages can be combined into 6, 8 or more linkages for the feeder mechanisms in film cameras, automatic lathes, farm machinery, and torch cutters.

KURT HAIN
Institute for Fundamental Research
Brunswick, Germany
Translated by F R Erskine Crossley, Yale University

When feeder mechanisms require complex curvilinear motions, it may be necessary to use compound linkages of more than four links. However, four-bar linkages can be synthesized to produce curvilinear motions of various degrees of complexity, and all possibilities of four-bar linkages should be considered before attempting the more complex types.

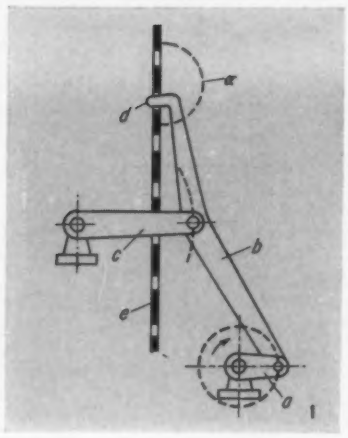
For example, a camera film-advancing mechanism, Fig 1, has a simple four-bar linkage with coupler point d which generates a curvilinear and straight-line motion α resembling a "D". Another more complex curvilinear motion, Fig 2, is also generated by a coupler point E of a four-bar linkage which controls an automatic profile cutter. Four-bar linkages can be used to generate a number of curvilinear motions as in Fig 3. Here the points of the coupler prongs, g_1, g_2, and g_3 on coupler b, and g_4 and g_5 on coupler e, are chosen in such a way that their motions result in the desired progressive feeding of straw into a press (manufactured by Gebr. Welger, Wolfenbuttel, Germany).

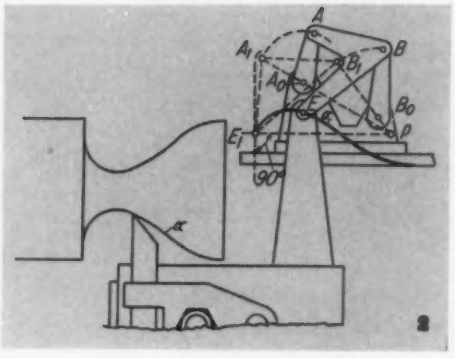
A similar feeding and elevating device (designed by Moertl in Germany) is shown in Fig 4. The rotating drive crank a moves coupler b and swinging lever c, which actuates the guiding arm f through the link e. The bar h carries the prone fingers g_1 through g_7. They generate coupler curves α_1 through α_7.

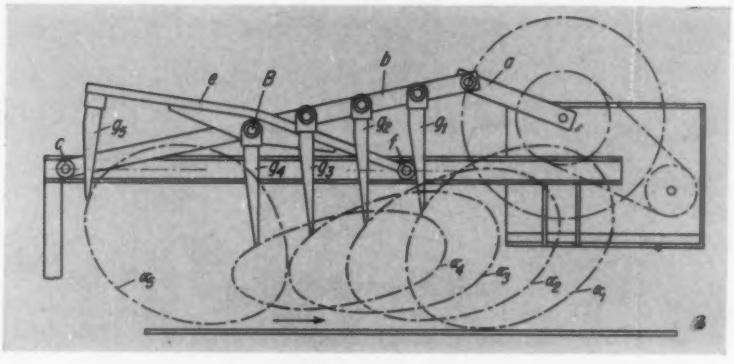
As another practical example, consider the torch-cutting machine in Fig 5(A) which is designed to cut sheetmetal along a curvilinear path α. Here the points A_0 and B_0 are fixed in the machine and the lever A_0A_1 is of adjustable length to suit different curvilinear paths α that may be desired.

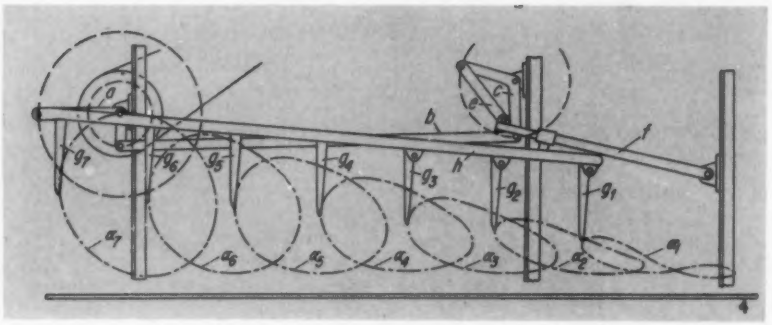
The length B_0B_1 is also fixed. The problem is to find the length of the levers A_1B_1 and E_1B_1 in the four-bar linkage to give the desired path α which is to be traced by the coupler point E on which the cutting torch is mounted.

The graphical solution for this problem as shown in (B) requires selection of the points A_1 and E_1 in such manner that the distances A_1E_1 to A_8E_8 are equal and the points





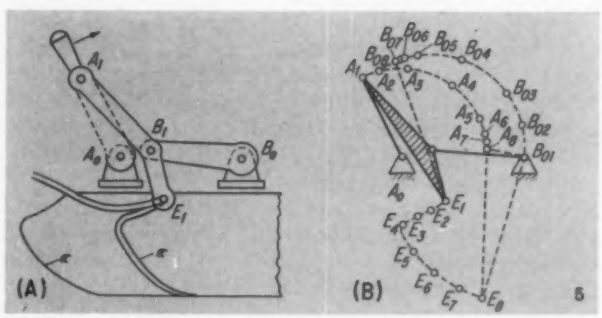




E_1 to E_8 lie on the desired coupler curved α. In this case only the points E_4 to E_8 represent the desired profile to be cut. The correct selection of points A_1 and E_1 depends upon making the following triangles congruent:

$$\Delta\, E_7\, A_2\, B_{01} = \Delta\, E_1\, A_1\, B_{02}$$
$$\Delta\, E_2\, A_2\, B_{01} = \Delta\, E_1\, A_1\, B_{03}$$
$$\Delta\, E_8\, A_8\, B_{01} = \Delta\, E_1\, A_1\, B_{08}$$

and so on until $E_8A_8B_{01} = E_1A_1B_{08}$. At the same time all points A_1 to A_8 must lie on the arc having A_0 as center, and all the points B_{01} to B_{08} must lie on the arc having B_1 as center.



Synthesis of an 8-bar linkage

Let us now design a linkage with 8 precision points, as shown in Fig 6. In this mechanism the curvilinear motion of one 4-bar linkage is coordinated with angular oscillation of a second four-bar linkage. The first four-bar linkage consists of AA_0BB_0 with coupler point E which

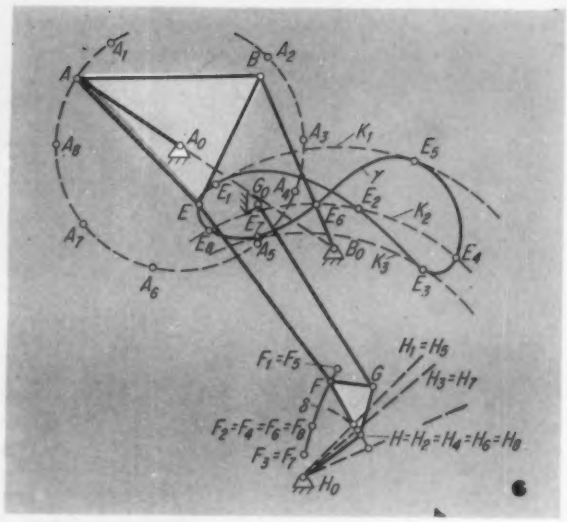
text continued, next page

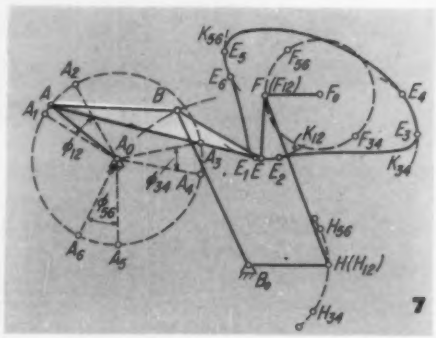
generates γ with 8 precision points E_1 through E_8 and drives a second four-bar linkage HH_0GG_0. Coupler point F generates curve δ with precision points F_1 through F_8. The coupler points F_2, F_4, F_6, F_8 are coincident, because straight links GG_0 and GH are in line with one another in these coupler positions. This is what permits HH_0 to oscillate despite the continuous motion of the coupler point F. The coupler points F_1 coincident with F_5, and F_3 coincident with F_7, have been chosen in such a way that F_1 is the center of a circle k_1 and F_2 is the center of a circle k_2. These circles are tangent to coupler curve γ at E_1, and E_6, E_2, and E_7; and they indicate the limiting positions of the second four-bar linkage HH_0GG_0.

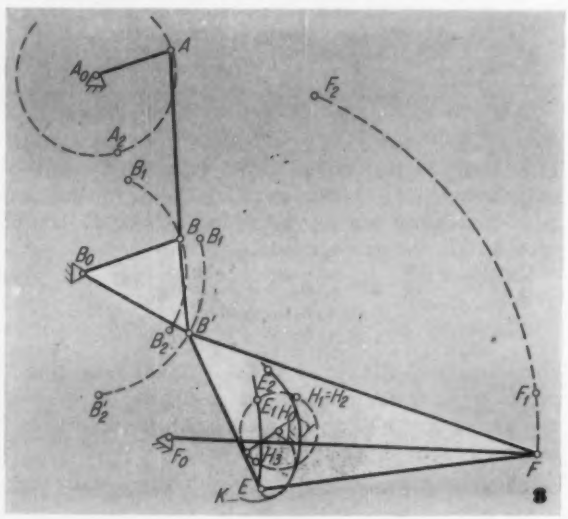
The limiting angular oscillation of HH_0, which is one of the requirements of this mechanism, is represented by positions H_0H_1 and H_0H_5. It oscillates four times for each revolution of the input crank AA_0, and the positions H_1 to H_8 correspond to input crank positions A_1 to A_8.

Synthesis of a compound linkage with dwell periods and coordinated intermittent motion is shown in Fig 7. The four-bar linkage AA_0BB_0 generates an approximately triangular curve with coupler point E, with six precision points E_1 through E_6. A linkage to do this is not unusual and can be readily proportioned from known methods of four-bar linkage synthesis. However, the linkage incorporates dwell periods which are used to produce coordinated intermittent motion by means of a second four-bar linkage FF_0HB_0. Here the tangent arc k_{12}, k_{34} and k_{56} are drawn with EF as radius from centers F_{12}, F_{34} and F_{56}, and these centers establish the circle with F_0 as the center and pivot point for the second four-bar linkage. Each tangent arc causes a dwell of the link FF_0, while AA_0 rotates continuously. Thus the link FF_0, with three rest periods in one revolution, can produce intermittent curvilinear motion in the second four-bar linkage FF_0HB_0. In laying out the center F_0 it must be so selected that the angle EFF_0 deviates only slightly from 90° because this will minimize the required torque that is to be applied at E. The length of B_0H can be made to suit, and the rest periods at H_{34}, H_{12} and H_{56} will correspond to crank angles ϕ_{34}, ϕ_{12} and ϕ_{56}.

A compound linkage can also produce a 360° oscillating motion with a dwell period as in Fig 8. The two four-bar linkages are AA_0BB_0 and BB_0FF_0, and the output coupler curve γ is traversed only through segment E_1E_2. The oscillating motion is produced by lever HH_0 connected to the coupler point by EH. The fixed point H_0 is located within the loop of the coupler curve γ. The dwell occurs at point H_3 which is the center of circular arc k tangent to the coupler curve γ during the desired dwell period, and in this case the dwell is made to occur in the middle of the 360° oscillation. The coincident positions H_1 and H_2 indicate the limiting positions of the link HH_0, and correspond to the positions E_1 and E_2 of the coupler point.







From the text for the Refresher Course in Mechanism 1959/1960, arranged and sponsored by the Chamber of Commerce & Industry of the City of Brunswick, Germany, in cooperation with the Division of The Science of Mechanism of the Society of German Engineers (VDI). Course director: Kurt Hain.

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9 COMMON FUNCTIONS OF THICKNESS

For values up to 1½ in., don't waste time with repetitive calculations, just plug in the answers from this list.

S WARREN KAYE
Raytheon Co
Bedford, Mass

Thickness shows up in one form or another in many equations. For example: moment of inertia of rectangular sections $I = bt^3/12$; maximum plate deflection $y = \alpha\ wa^4/Et^3$; or maximum plate stress $S = \beta\ wa^2/t^2$.

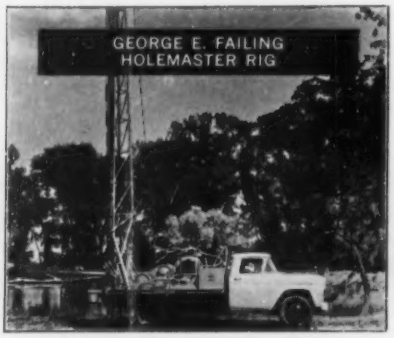
To save calculating time, especially for long repetitive series, refer to these tabulations of often-used fractions and powers. Included are values of Et^3—the modulus of elasticity times thickness—for aluminum and steel.

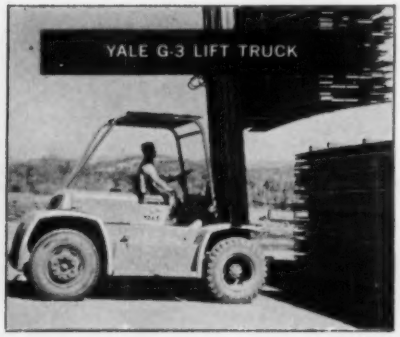
VALUES OF COMMON FUNCTIONS OF THICKNESS

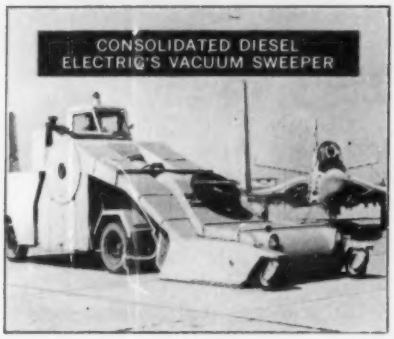
t, in.	t^2	$1/t^2$	$t^2/6$	t^3	$t^3/12$	t^4	πt	Et^3 (Aluminum)	Et^3 (Steel)
0.01	0.000,10	10,000.0	0.000,016,7	0.000,00	0.000,0	0.000,0	0.031,416	0	0
0.02	0.000,40	2,500.0	0.000,066,8	0.000,01	0.000,0	0.000,0	0.062,832	100	290
0.03	0.000,90	1,111.10	0.000,150,3	0.000,03	0.000,0	0.000,0	0.094,247	300	870
0.04	0.001,60	625.0	0.000,267,2	0.000,06	0.000,01	0.000,0	0.125,664	600	1,740
0.05	0.002,50	400.0	0.000,417,5	0.000,13	0.000,01	0.000,01	0.157,079	1,300	3,770
0.06	0.003,60	278.0	0.000,601,2	0.000,22	0.000,02	0.000,01	0.188,495	2,200	6,380
0.07	0.004,90	204.0	0.000,818,3	0.000,34	0.000,03	0.000,02	0.219,911	3,400	9,860
0.08	0.006,40	156.0	0.001,068,8	0.000,51	0.000,04	0.000,04	0.251,327	5,100	14,790
0.09	0.008,10	123.0	0.001,352,7	0.000,73	0.000,06	0.000,07	0.282,743	7,300	21,170
0.10	0.010,00	100.0	0.001,666,7	0.001,00	0.000,08	0.000,10	0.314,159	10,000	29,000
0.11	0.012,10	82.644	0.002,020	0.001,33	0.000,11	0.000,15	0.345,575	13,300	38,570
0.12	0.014,40	69.444	0.002,404,8	0.001,73	0.000,14	0.000,21	0.376,991	17,300	50,170
0.13	0.016,90	59.171	0.002,822,3	0.002,20	0.000,18	0.000,29	0.408,407	22,000	63,800
0.14	0.019,60	51.020	0.003,273,2	0.002,74	0.000,23	0.000,38	0.439,823	27,400	79,460
0.15	0.022,50	44.444	0.003,757,5	0.003,38	0.000,28	0.000,51	0.471,239	33,800	98,020
0.16	0.025,60	39.062	0.004,275,2	0.004,10	0.000,34	0.000,66	0.502,654	41,000	118,900
0.17	0.028,90	34.600	0.004,826,3	0.004,91	0.000,41	0.000,84	0.534,070	49,100	142,390
0.18	0.032,40	30.864	0.005,410,8	0.005,83	0.000,49	0.001,05	0.565,486	58,300	169,070

continued, page 59

Q: WHY DO LEADING OEM'S USE FORD POWER?







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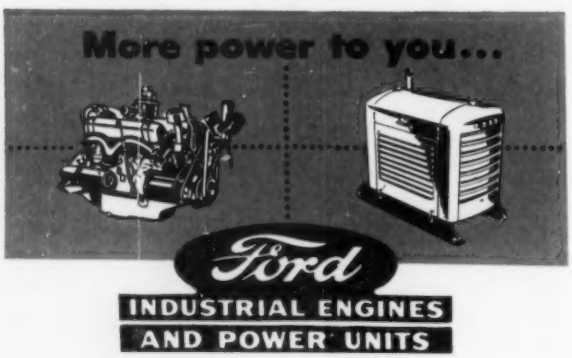

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FUNCTIONS of THICKNESS continued

t, in.	t^2	$1/t^2$	$t^2/6$	t^3	$t^3/12$	t^4	πt	Et^3 (Aluminum)	Et^3 (Steel)
0.19	0.036,10	27.700	0.006,028,7	0.006,86	0.000,57	0.001,30	0.596,902	68,600	198,940
0.20	0.040,00	25.000	0.006,680,0	0.008,00	0.000,67	0.001,60	0.628,318	80,000	232,000
0.21	0.044,10	22.675	0.007,364,7	0.009,26	0.000,77	0.001,94	0.659,734	92,600	268,540
0.22	0.048,40	20.661	0.008,082,8	0.010,65	0.000,89	0.002,34	0.691,150	106,500	308,850
0.23	0.052,90	18.903	0.008,834,3	0.012,17	0.001,01	0.002,80	0.722,566	121,700	352,930
0.24	0.057,60	17.361	0.009,619,2	0.013,82	0.001,15	0.003,32	0.753,982	138,200	400,780
1/4	0.062,50	16.000	0.010,437,5	0.015,63	0.001,30	0.003,91	0.785,398	156,300	453,270
9/32	0.079,10	12.642	0.013,209,7	0.022,25	0.001,85	0.006,26	0.883,572	222,500	645,250
5/16	0.097,66	10.239	0.016,309,0	0.030,52	0.002,54	0.009,64	0.981,747	305,200	885,080
11/32	0.118,16	8.463,1	0.019,732,7	0.040,62	0.003,38	0.013,96	1.079,92	406,200	1,177,980
3/8	0.140,63	7.110,8	0.023,485,0	0.052,73	0.004,39	0.019,78	1.178,096	527,300	1,529,170
13/32	0.165,04	6.059,1	0.027,561,7	0.067,05	0.005,59	0.027,24	1.276,270	670,500	1,944,450
7/16	0.191,41	5.224,3	0.031,965,0	0.083,74	0.006,98	0.036,64	1,374,445	837,400	2,428,460
15/32	0.219,73	4.551,0	0.036,694,9	0.103,00	0.008,58	0.048,28	1.472,620	1,030,000	2,987,000
1/2	0.250,00	4.000,0	0.041,750,0	0.125,00	0.010,42	0.062,50	1,570,795	1,250,000	3,625,000
17/32	0.282,23	3.543,2	0.047,132,4	0.149,93	0.012,49	0.079,65	1,668,970	1,499,300	4,347,970
9/16	0.316,41	3.160,4	0.052,840,5	0.177,98	0.014,83	0.100,11	1.767,140	1,779,800	5,161,420
19/32	0.352,54	2.836,5	0.058,874,0	0.209,32	0.017,44	0.124,28	1.865,32	2,093,200	6,070,280
5/8	0.390,63	2.559,9	0.065,235,0	0.244,14	0.020,35	0.152,59	1.963,49	2,441,400	7,080,060
21/32	0.430,66	2.322,0	0.071,920,2	0.282,62	0.023,55	0.185,47	2.061,67	2,826,200	8,195,980
11/16	0.472,66	2.115,6	0.078,934,0	0.324,95	0.027,08	0.223,40	2,159,84	3,249,500	9,423,550
23/32	0.516,60	1.935,7	0.086,272	0.371,31	0.030,94	0.266,88	2,258,02	3,713,100	10,767,990
3/4	0.562,50	1.777,7	0.093,937,5	0.421,88	0.035,16	0.316,41	2.356,19	4,218,800	12,234,520
25/32	0.610,35	1.638,4	0.101,928,0	0.476,84	0.039,74	0.372,53	2.454,37	4,768,400	13,828,360
13/16	0.660,16	1.514,7	0.110,246,0	0.536,38	0.044,70	0.435,81	2.552,54	5,363,800	15,555,020
27/32	0.711,91	1.404,6	0.118,889	0.600,68	0.050,06	0.506,82	2.650,72	6,006,800	17,419,720
7/8	0.765,63	1.306,1	0.127,860	0.669,92	0.055,83	0.586,18	2.748,89	6,699,200	19,427,680
29/32	0.821,29	1.217,5	0.137,155	0.744,29	0.062,02	0.674,52	2.847,06	7,442,900	21,584,410
15/16	0.878,91	1.137,7	0.146,777,9	0.823,97	0.068,66	0.772,48	2.945,24	8,239,700	23,895,130
31/32	0.938,48	1.065,5	0.156,726	0.909,15	0.075,76	0.880,74	3.043,42	9,091,500	26,365,350
1	1.000,00	1.000,0	0.167,000	1.000,00	0.083,33	1.000,00	3.141,59	10,000,000	29,000,000
1 1/32	1.063,48	0.940,30	0.177,601	1.096,71	0.091,39	1.130,98	3.239,76	10,967,100	31,804,590
1 1/16	1.128,91	0.885,81	0.188,528	1.199,46	0.099,96	1.274,43	3.337,94	11,994,600	34,784,340
1 3/32	1.196,29	0.835,91	0.199,780	1.308,44	0.109,04	1.431,11	3,436,11	13,084,400	37,944,760
1 1/8	1.265,63	0.790,10	0.211,360	1.423,83	0.118,65	1.601,81	3.534,28	14,238,300	41,291,070
1 5/32	1.336,91	0.747,99	0.223,264	1.545,81	0.128,82	1.787,34	3.632,46	51,458,100	44,828,490
1 3/16	1.410,16	0.709,13	0.235,496	1.674,56	0.139,55	1.988,54	3.730,64	16,745,600	48,562,240
1 7/32	1.485,35	0.673,24	0.248,053	1.810,27	0.150,86	2.206,27	3.828,81	18,102,700	52,497,830
1 1/4	1.562,50	0.640,00	0.260,937	1.953,12	0.162,76	2.441,41	3.926,98	19,531,200	56,640,480
1 9/32	1.641,60	0.609,16	0.274,147	2.103,30	0.175,28	2.694,86	4.025,16	21,033,000	60,995,700
1 5/16	1.722,66	0.580,49	0.287,684	2.260,99	0.188,42	2.967,54	4.123,34	22,609,900	65,568,710
1 11/32	1.805,66	0.553,81	0.301,545	2.426,36	0.202,20	3.260,42	4.221,51	24,263,600	70,364,440
1 3/8	1.890,63	0.528,92	0.315,735	2.599,61	0.216,63	3.574,46	4.319,68	25,996,100	75,388,690
1 13/32	1.977,54	0.505,67	0.330,249	2.780,91	0.231,74	3.910,66	4.417,86	27,809,100	80,646,390
1 7/16	2.066,41	0.483,93	0.345,090	2.970,46	0.247,54	4.270,03	4.516,03	29,704,600	86,143,340
1 15/32	2.157,23	0.463,55	0.360,257	3.168,43	0.264,04	4.653,63	4.614,21	31,684,300	91,884,470
1 1/2	2.250,00	0.444,44	0.375,00	3.375,00	0.281,25	5.062,50	4.712,39	33,750,000	97,875,000

By our method of reporting unemployment...

We're Giving The United States A Black Eye That Is Not Deserved

The way in which our unemployment is reported is giving the United States an undeserved black eye around the world. The broad concept of unemployment we use exaggerates the amount of unemployment in the United States as compared to most other countries. Our reporting system also falls short of presenting a balanced picture by concentrating on people who are idle, while neglecting jobs that are idle because people cannot be found to fill them. This editorial explains these defects and suggests improvements.

The *Monthly Bulletin of Statistics*, issued by the Statistical Office of the United Nations, has become a standard reference for international comparisons of economic performance, including employment and unemployment. Here, from the November, 1960 issue, is part of a table giving comparative figures on the rate of unemployment for the United States and a group of European countries:

	UNEMPLOYMENT RATE	
	Annual Average 1959	Jan.-June Average 1960
West Germany	2.4%	1.0%
Netherlands	1.8	1.4
Sweden	2.0	1.8
United Kingdom	2.3	1.9
United States	5.5	6.1

A Distorted Picture

If taken at face value the table clearly says that the United States is doing far worse in providing jobs for its citizens than the other countries whose unemployment records are listed.

But the figures are deceptive. They are made so, in part, by our government's use of a much broader concept of what constitutes unemployment than is used by most other countries.

Sweden provides a clear case in point. The table indicates that during 1959 Sweden had an unemployment rate of 2.0%, while the rate in the

United States was 5.5%. But a report from Sweden, published in the U.S. Department of Labor's *Labor Developments Abroad*, indicates that if they had used the same methods of calculating unemployment as we, the reported jobless rate in Sweden would have almost doubled. Thus a large portion of the gap between the unemployment rate in the United States and the unemployment rate in Sweden would have been eliminated.

Graduation To Unemployment

In general, countries listed in the table use registrations at public employment agencies as the basis for calculating their unemployment. Our Department of Labor, in making its sampling of unemployment, includes unregistered young people who are waiting for jobs or training opportunities as well as housewives who are looking for jobs in a general sort of way but who have not registered anywhere in search of them.

It used to be that graduation from college was regarded as a day for great celebration and rejoicing. But, because of the way the Labor Department does its counting of unemployment, it is now a day of sorrow. For unless our young people immediately rush off to jobs, they graduate into unemployment and swell our jobless figures.

While our government very expansively counts all the unemployed, there is no offsetting report on the number of jobs that are unfilled because no one qualified can be found to fill them. Currently there are many jobs in this category, and it is to be expected that there will be more as the technological revolution picks up momentum.

A properly balanced report on unemployment would include a record both of people who are idle, as conceived on some standard international basis, and jobs that are idle. A combination of the two sets of data would provide a much better indication of the economic health of a nation than unemployment alone.

The United Kingdom regularly collects figures on unfilled jobs as well as the number of unemployed. Thus it is not an impossible task to collect information on idle jobs. **For a fast moving economy, such as ours, the collection of statistics on unfilled jobs presents special difficulties. But this information is so important that Congress should see that it is added to our employment and unemployment records.**

A National Disservice

There is not the slightest inclination here to minimize the amount of unemployment in the United States at any time, or the crucial importance of doing everything possible to keep it at rock bottom. If the reporting of unemployment were simply for domestic consumption, it would be possible to make an appealing case for using a very broad conception of it. This is one way of underlining the importance of the problem.

But when, as is the case, international comparisons of unemployment are treated as key gauges of the effectiveness of different economies, we do ourselves an important national disservice by using an exceptionally commodious concept of unemployment. American travelers abroad can testify that they are continuously being called upon to explain why the United States does such a relatively poor job in providing employment for its people. This is an unwise and unfair burden to impose upon the nation. **We make enough mistakes of economic commission and omission without issuing reports that distort our economic performance to our own discredit abroad.**

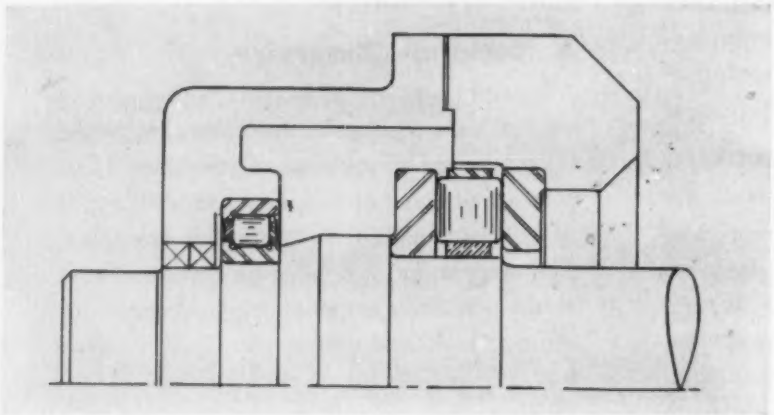
This message was prepared by my staff associates as part of our company-wide effort to report on major new developments in American business and industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.

Donald C. McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Cantilever thrust bearing . . .
is said to withstand deflection loading, reducing failures caused by lack of squareness between shaft and housing components. Finished on one side for applying load to roller assembly, bearing plates are thicker than usual to carry deflection loading. Thickness is calculated so that plates' working surfaces stay parallel where rollers contact. Crowned rollers reduce end stresses between rollers and thrust plates for increased thrust capacity. Bearings range in size from 4 to 17-in. bore and from 7½ to 34-in. OD. Delivery in 90 to 120 days. **Rollway Bearing Co, 541 Seymour St, Syracuse, NY.**

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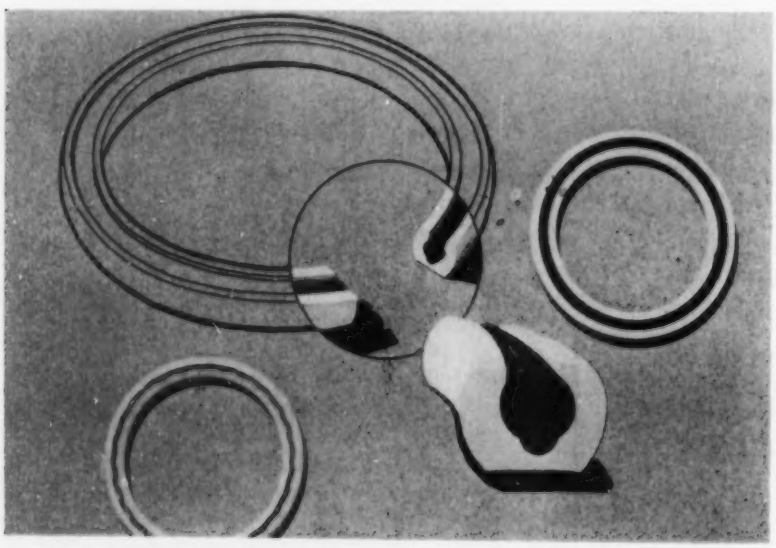

Spring expander inside Teflon . . .
seal ring overcomes material's tendency to shrink away from sealing surfaces when temperatures are reduced. Rings range in size from ⅛ to 15 in. ID and have either stainless steel or synthetic rubber expanders. Tested as a rod seal, ring reportedly allowed no perceptible leakage after 400,000 cycles at 3000 psi and at 400 F. Priced from $4.60 to $172.50 each in quantities of 1 through 9. Delivery in 2 wk or less. **Tanner Engineering Co, 1003 Santa Fe Ave, Los Angeles 21.**

Circle 301 on Reader Service Card

Explosionproof limit switch
for hazardous areas, has trip differential of 6°, ±1°; repetitive accuracy of ±0.1°; safety overtravel in both directions of 45°; and operating force of 60 oz-in. max to trip. Electrical circuits are one normally open, one normally closed, fully isolated double break, 600 v, ac or dc. Switch, minus lever, is priced at $24. Five lever types range from $1 to $2.50. **Denison Mfg Co, 386 Broadway, Bedford, Ohio.**

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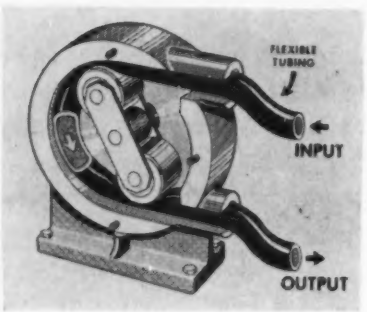

Pump allows no contact . . .
between moving parts and fluid being pumped. Intake and outlet are one continuous flexible tube which passes through pump body and is exposed to squeegee action of rotor with two ball-bearing rollers. With proper tubing, corrosive, sterile and abrasive liquids or gases can be pumped without contamination or injury to pump. Available in two sizes—54 and 185 gph at 575 rpm—with or without ¼-hp motor or speed controls. Prices start at $68.50. **Randolph Co, 1018 Rosine St, Houston 19, Tex.**

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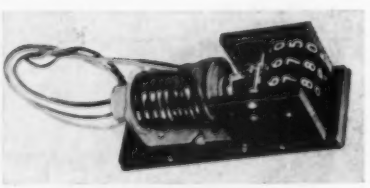


Miniature impulse counter . . .
provides declining readings in 5-unit increments from "995" to "000". Useful for functions requiring events indication or program items readout. Weighs slightly more than 4 oz and

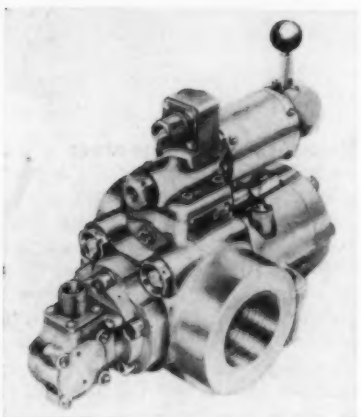
measures less than 1 in. sq x 3 in. long. Counter window is ⅜ in. high and white characters on dull black wheels are 0.156 in. tall. Max response speed is 1320 impulses per min, providing full scale or cycle of operation in 9 sec. Required input is 10 through 12 v dc at 2 w, but actuation from other conventional input voltages can be substituted. Suitable at altitudes to 70,000 ft and temperatures from −4 to 159.8 F. Designed for 80%—on, 20%—off operation. **Bowmar Instrument Corp, 8000 Bluffton Rd, Fort Wayne, Ind.**

Circle 304 on Reader Service Card

Abrasion-resistant surfacing material . . .

is pure vinyl backed with asbestos. Said to be completely inert, highly flexible, unaffected by alkaline moisture and easily bonded to all subsurfaces with wide variety of adhesives. Available in green, blue, fawn, turquoise, gray, maroon and red in die-cut parts up to 54 in. or in 60-sq-yd rolls. **Industrial Div, Armstrong Cork Co, Lancaster, Penna.**

Circle 305 on Reader Service Card



High-pressure pneumatic valve . . .

has pressure-sensing actuator with pneumatic timer and downstream pressure feedback which control movements of large slave poppet, providing automatic programed operation. Threat of spontaneous ignition during heat-generating pressure surges is said to be eliminated. Valve operates with pressure differential of 0 through 6000 psi applied in either direction; ambient and line temperatures of −65 to 160 F. Available for 1¼-in. tube size. **Marotta Valve Corp, Boonton, NJ.**

Circle 306 on Reader Service Card

Embossing technique . . .

adds virtually any embossed design to stainless steel, aluminum and anodized aluminum shapes without breaks in the pattern. Suitable for applications in which shapes are subject to surface scratches. Embossed patterns can be incorporated for cost of embossing die alone and do not hinder punching, notching, etc, in shape itself. **Roll Formed Products Co, 3760 Oakwood Ave, Youngstown, Ohio.**

Circle 307 on Reader Service Card

Machinery mount . . .

is said to dampen and isolate vibration as much as 85%. Consists of cast-steel base plate (bonded to a heavy pad of composition material) and leveling screw assembly. Base plate and pad are 1 in. high, providing max rigidity for mount. Suitable for most machine tools, except shapers, heavy-duty punch presses and similar units. **Clark, Cutler, McDermott Co, Franklin, Mass.**

Circle 308 on Reader Service Card

Temperature sensor . . .

for −320 to 280 F service, can either measure skin temperatures and level of liquid nitrogen or act as temperature compensation element for constant signal readout. Time constant for 63.2% of temperature span is better than 700 millisec, and time response at 99% for step temperature is less than 5 sec. Functions as one arm of four-arm bridge and withstands 100 g's at 100 to 700 cps. **Crescent Engineering & Research Co, 5440 N Peck Rd, El Monte, Calif.**

Circle 309 on Reader Service Card

Proximity limit switch . . .

uses an alternating magnetic field, which is distorted by ferrous or nonferrous metal objects moving in close proximity (up to 1 in.) to pickup. Distortion is sensed by pickup, and a voltage is developed which is used to operate a control unit relay. Mercury switch allows no contact wear. Input power is either 110 v ac or 110 v dc; input power consumed, 2 w; and output contact rating, 250 v-amp, 500 v max. Standard models, with transistor-equipped control and pickup unit, start at $72. Delivery in 1 to 2 wk. **Electronic Signals Inc, PO Box 3811, Cleveland 10.**

Circle 310 on Reader Service Card

Visual readout instrument . . .

displays 64 individual characters when operated from a 6-bit binary input, or 16 characters when operated from a 4-bit binary input. Internally-lighted display changes from one character to any other within 50 millisec. Locking device holds any individual character without drain on command input circuit. Unit weighs 5.5 oz, including connector, and measures 4.5 x 1.18 x 1 in. Characters, each 0.5 in. high and 0.31 in. wide, can be read from 30 ft and within 90% viewing angle. **Servomechanisms Inc, 200 N Aviation Blvd, El Segundo, Calif.**

Circle 311 on Reader Service Card

Electric impulse counter . . .

reaches speeds of 250 impulses per sec. Consists of cold cathode counting tube, transistor-equipped pulse shaper-amplifier and totalizing counter. As each 10 impulses are registered, the impulse counter advances one digit. Thus, drum becomes tens drum, and with rating of 25 impulses per sec, package counting speed of 250 impulses per sec is achieved. Unit measures 5 1/8 x 2 13/16 x 8 5/32 and requires approx 16.5 w, 110 v, single phase power. **Landis & Gyr Inc, 45 W 45th St, New York 36.**

Circle 312 on Reader Service Card

Phenolic binder for glass-fabric-reinforced laminate . . .

has heat resistance comparable to silicone binder and adds more flexural strength at all temperatures to the material. In weight loss and erosion tests, phenolic laminates closely approach glass-silicone laminates and exceed glass-melamine and glass-polyester laminates. Material is suitable for applications requiring combination of stability against thermal shock; high strength-to-weight ratio; low thermal conductivity and high percentage of strength retained for more than 300 hr at temperatures to 500 F. Density of

continued on page 64

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material is 1.94 gm/cu cm; ultimate flexural strength, 74,000 psi; and ultimate tensile strength, 50,000 psi. **Westinghouse Electric Corp, Micarta Div, Box 2278, Pittsburgh 30.**

Circle 313 on Reader Service Card

Miniature checkvalve . . .

has total pressure drop of less than 1 psi at rated flow. Max cracking pressure is 8 in. water, while total pressure drop does not exceed 20 in. water at rated flow. Designed for applications where operating pressures do not exceed 60 psi, valve is compatible with 90% hydrogen peroxide, nitric acids and other fuels. Available in tube sizes from ¼ to 1¼ in. **Spartan Mfg Corp, 445 Saw Mill River Rd, Yonkers, NY.**

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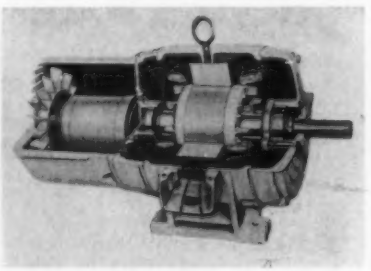


Rapid-reversing motors . . .

reach 125 idle reversals per min. in smaller sizes with open type construction and over 200 idle reversals per min. with blower-cooled design. Stators are built with large, special-shape slots for max copper in windings. Rotors in smaller size motors are cast aluminum with special slot design and low inertia construction, while larger sizes have high-resistance bar rotor construction. **Louis Allis Co, Dept P, 427 E Stewart St, Milwaukee 1.**

Circle 315 on Reader Service Card

Linear-motion potentiometer

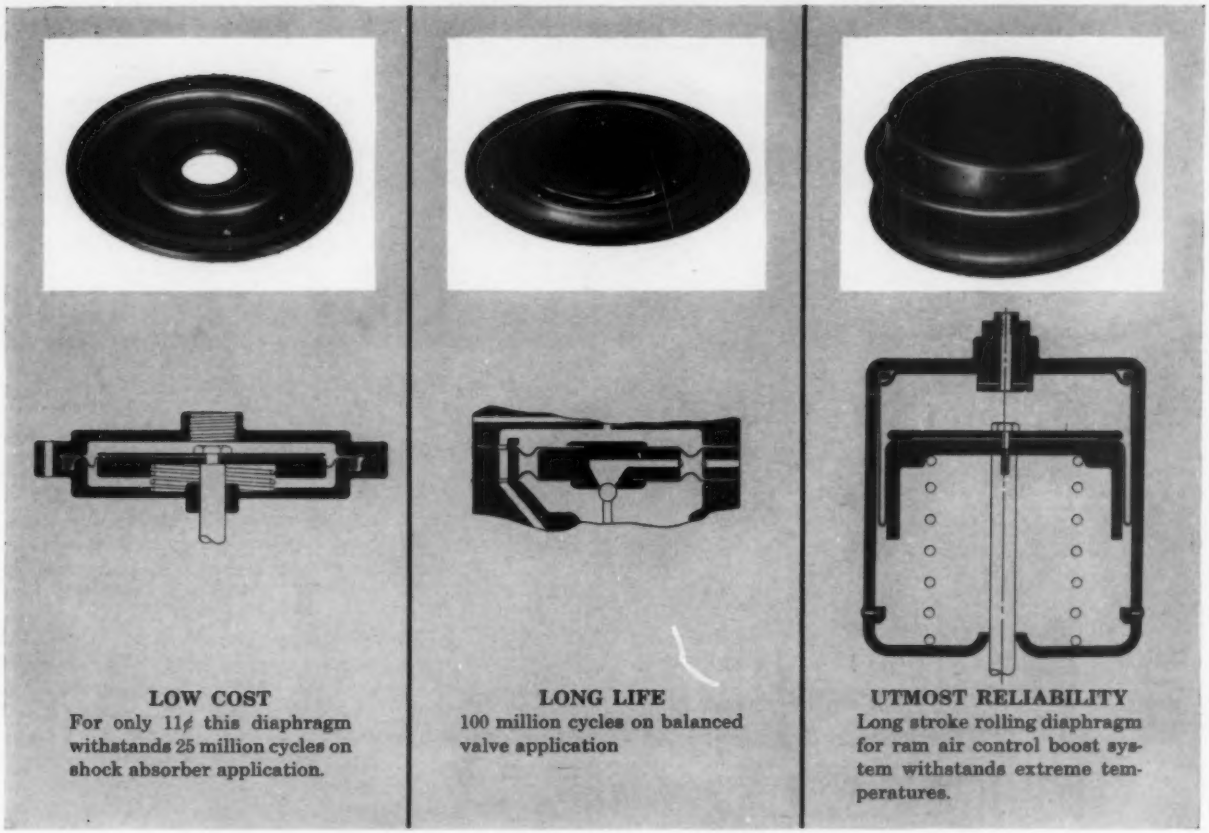
made of conductive plastic, has wire-wound element with high resolution and standard linearity of 0.05% (closer linearity on request). Stroke is 12 in., and sizes range from 2 to 24 in. in length. **New England Instrument Co, 1334 Main St, Waltham, Mass.**

Circle 316 on Reader Service Card

Floatless level control . . .

for use with liquids of low specific resistance, reportedly will not contaminate products. Low electrode potential of 9 v ac, combined with low electrode current

continued on page 66



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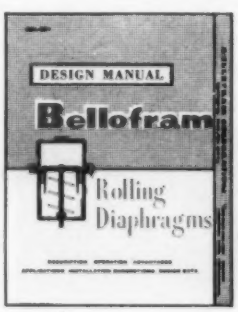

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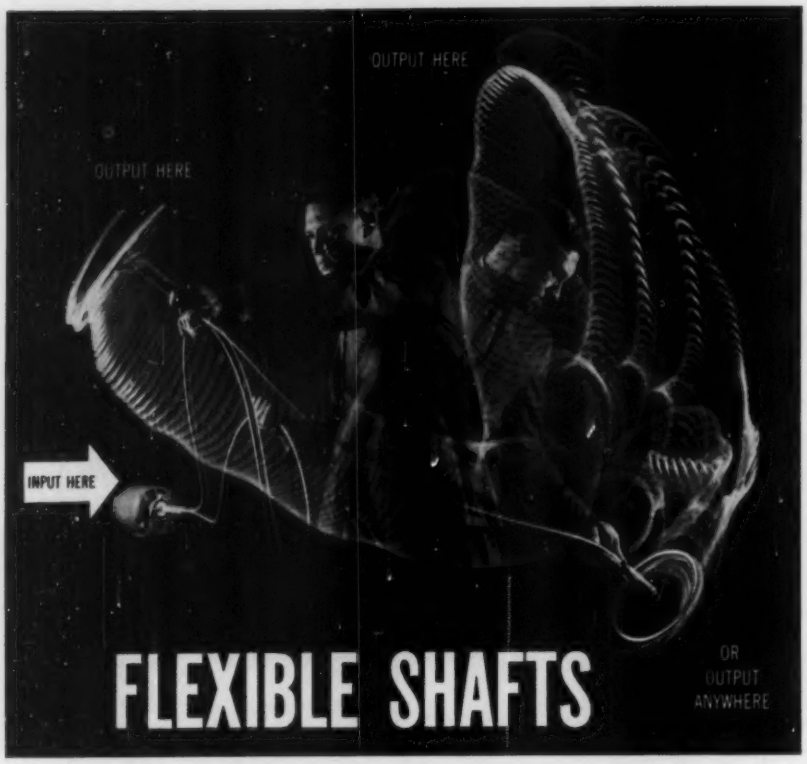

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of less than 25 milliamp, eliminates shock and sparking hazards. Has interchangeable terminal wiring for either direct or inverse operation. Sensitivity is determined by value of fixed resistor mounted on terminal strip. Selection of proper resistor depends on specific resistance of liquid to be controlled. Control applications possible include from 120 to 4700 ohm in direct operation and from 340 to 10,000 ohm in inverse operation. **B/W Controller Corp, 2200 E Maple Rd, Birmingham, Mich.**

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Precoated strip steel . . .

is produced by treating steel with a solution combining phosphate and animal fats. Reacting with carbon steel surface, solution produces a phosphate coating which not only acts as an anchor for a film of fatty lubricant but also separates steel from die or forming tool during forming process. Neither coating interferes with welding. Subsequent to forming, a hot alkaline bath removes the oily lubricant and a weak acid bath removes the phosphate coating. If part is to be painted, it is recommended that phosphate coating be used as a base. Strip is available in coils up to 22 in. wide and cut lengths up to 24 in. **Pittsburgh Steel Co, Grant Bldg, Pittsburgh 30.**

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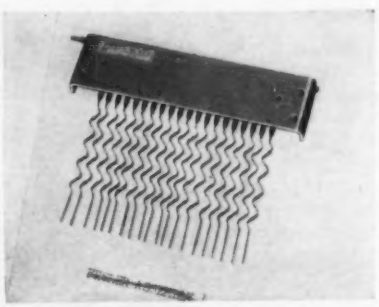

Missing-parts detector . . .

has high-impedance feeler assembly unaffected by water or oil. Automatically detects non-ejection, misfeeding, buckling, end-of-material or overloading and stops equipment instantaneously. Priced at $285. **Wintriss Controls, Div Idustrionics Controls Inc, 20-24 Vandam St, New York 13.**

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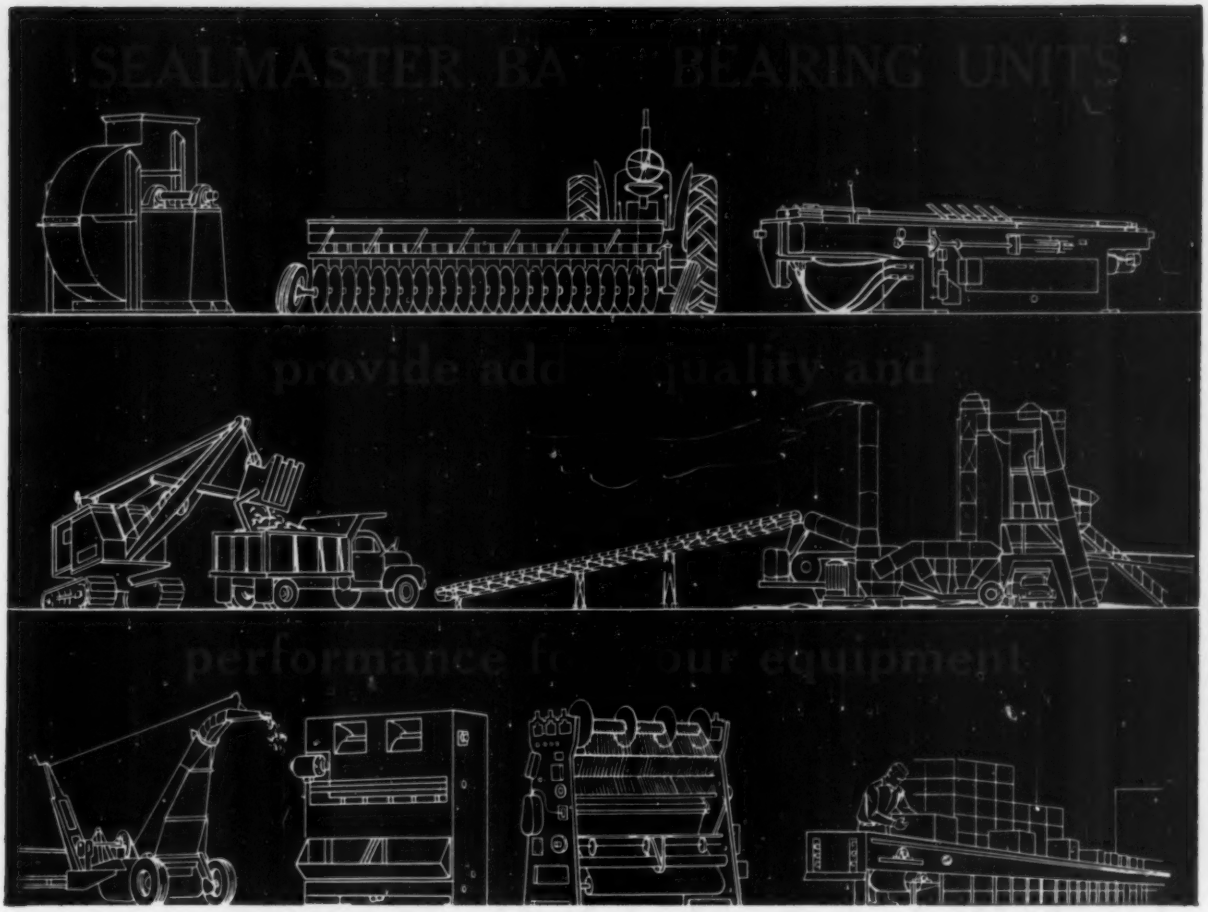
Fractional-hp ac motors . . .

rated from 1/400 to ¼ hp, operate on 60 cps and have ambient range of —67 to 257 F. Available as either induction or hysteresis synchronous, self-cooled or

continued on page 68



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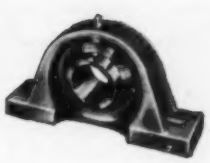

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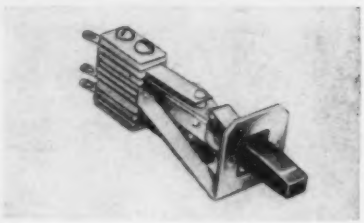
totally-enclosed, finned or plain unit. Speeds are either 1- or 3-phase, 2- or 4-pole. Finned version has 3¾-in. dia; plain unit, 3 5/16-in. dia. **Air Marine Motors Inc, Bayview Ave, Amityville, LI, NY.**

Circle 320 on Reader Service Card

Immersion alarm thermostat . . .

for liquid-cooled engines and oil-cooled transformers, is small enough not to impede flow of circulating liquids. Useful in conjunction with alarm devices, pilot lights, solenoids and relays. Contacts are normally open and close with rise in temperature. Has ¼-in. pipe-threaded body which serves as a grounding terminal, and over-all dimensions of 2 x 7/8 in. Available for operating temperatures to 300 F. **George Ulanet Co, 413 Market St, Newark 5, NJ.**

Circle 321 on Reader Service Card



Short-frame toggle switches

have relatively long springs without "forms" at point of flexing. This is said to provide long "spring-action" life. Contacts are rated at 3 amp, 120 v ac noninductive load (300 v max). Can be mounted on ¾-in. centers with No. 3 through 48 machine screws. **Switchcraft Inc, 5555 N Elston Ave, Chicago 30.**

Circle 322 on Reader Service Card

Porcelain enamel nameplates . . .

can be drilled, bent, formed, cut or stamped and enamel will not chip or break away from metal. Finish is non-fading; resistant to solvents, oil, acids, alkalies, moisture, corrosion, etc, and available in any design and any combination of colors. **Erie Ceramic Arts Co, 3120 W 22nd St, Erie, Penna.**

Circle 323 on Reader Service Card

Miniature circuit breakers . . .

for remote indicators and alarms, have voltage ratings of 50 v dc and 120 v rms, 60 or 400 cps; and current ratings of 50 milliamp to 10 amp. Instantaneous-acting types are available, as well as those

continued on page 70

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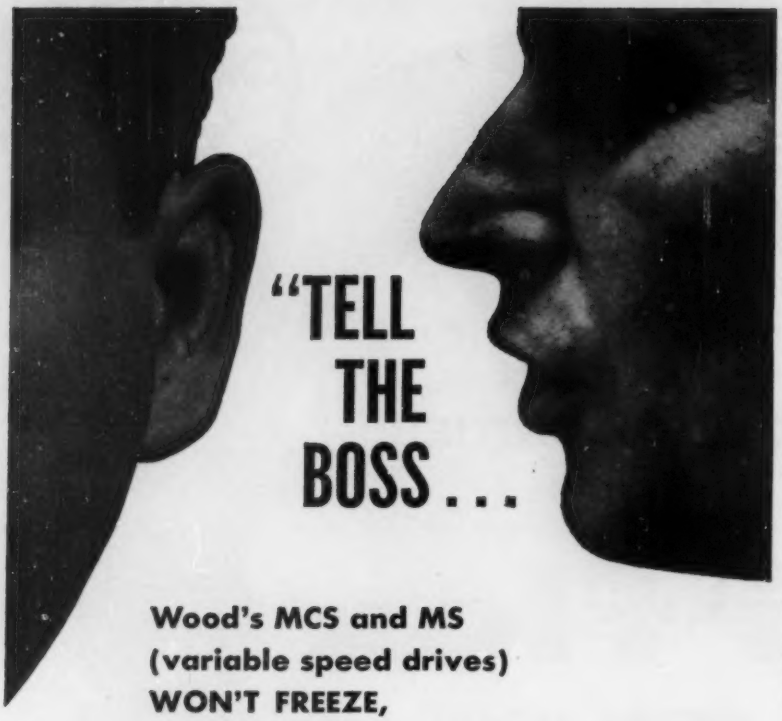

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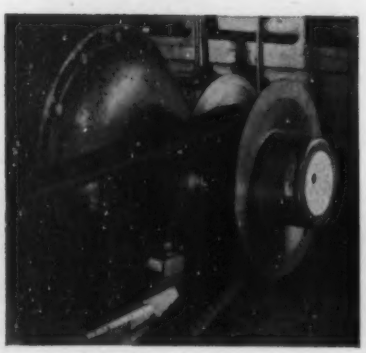
And, remind him that Wood's MCS and MS motion control drives solve production and maintenance problems no other mechanical variable speed drives can handle. They won't freeze or stick because there are no keys to obstruct lubrication of bearing surfaces. Revolutionary resilient cam followers or pads, located outside the bearing surfaces, permit continuous rotational pumping action, assure even distribution of oil. And, you check lubrication only three or four times a year. Also, Wood's MCS drives hold constant driven speeds under varying torque loads.



Wood's motion control, variable speed drives are available in capacities from fractional to 25 hp. If you and the boss want more information about these remarkable drives, write for BULLETIN 25103.

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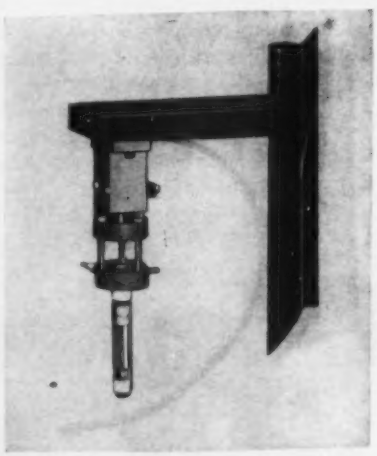
with short-time delays of about 3 sec or long-time delays of about 30 sec. SPDT switching action of auxiliary contacts, rated for 1 amp, 110 v rms, provides fast, positive indication when breaker trips. Delivery in 1 to 3 wk. **Airpax Electronics Inc, Cambridge Div, Cambridge, Md.**

Circle 324 on Reader Service Card

Modular-design rotary switch

rated 20 amp, 600 v ac, can be used for motor control up to 16 hp at 600 v, as well as for instrumentation and control circuits. Contains two isolated, double-break, silver-alloy contacts in each stage. Twelve stages can be combined to form single column of 24 contacts, while up to 4 columns, arranged in tandem, controls up to 96 double-break contacts over 18 positions, from a single control point. Latching mechanism is available for 90°, 60°, 45° and 30° throw. Unit reportedly lasts for 5 million operations. Delivery in 1 to 2 wk. **American Solenoid Co Inc, US Hghwy 22, Union, NJ.**

Circle 325 on Reader Service Card



Electrochemical marking kit

can be built into automatic production lines or machines, with no redesign or modification required before installation.

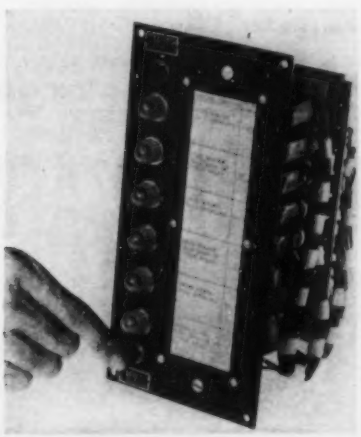
Consists of pneumatic marking head and JIC cabinet, completely piped and wired. Requires both compressed air and electricity for operation. Control cabinet has marking-dwell and off-cycle timers; marking-intensity meter; mark-depth rheostat; 4-way solenoid and pressure-regulating valve; setup switch; and indicating lights and switches for all functions. Marking cycle itself is fully automatic and can be adjusted to accommodate size and depth of mark and material to be marked. Marking heads are available in round, square, or rectangular shapes from $\frac{3}{8}$ in. to 10 sq in. **Electromark Corp, 2093 E 19th St, Cleveland 15.**

Circle 326 on Reader Service Card

Neon indicator . . .

rated at 0.001 amp at 115 v ac, has built-in 62,000-ohm resistor. Weighing 0.020 lb, unit is front- or rear-panel mounted and uses MS25252 NE20 lamp. Lens come in three colors. **Control Switch Div, Controls Company of America, Folcroft, Penna.**

Circle 327 on Reader Service Card



Static faultfinder . . .

has static magnetic type switching and memory type operation. Low-voltage incandescent lamps indicate faults and malfunctions in electrical control equipment. Each lamp remains lighted until manually reset even though fault has been cleared. If, however, a fault has not been cleared, it will reappear when "reset" button is released. Unit, composed of six full-wave, self-saturating magnetic amplifiers, monitors one to six individual devices. Operates with 115 to 300 v dc or 120 v, 60-c control circuits. Input power is 115 v, 60 c. Available with or without enclosure. Enclosed unit is priced at $370; open unit, $362. Delivery in 7 to 8 wk. **Clark Controller Co, 1146 E 152nd St, Cleveland 10.**

Circle 328 on Reader Service Card

continued on page 73

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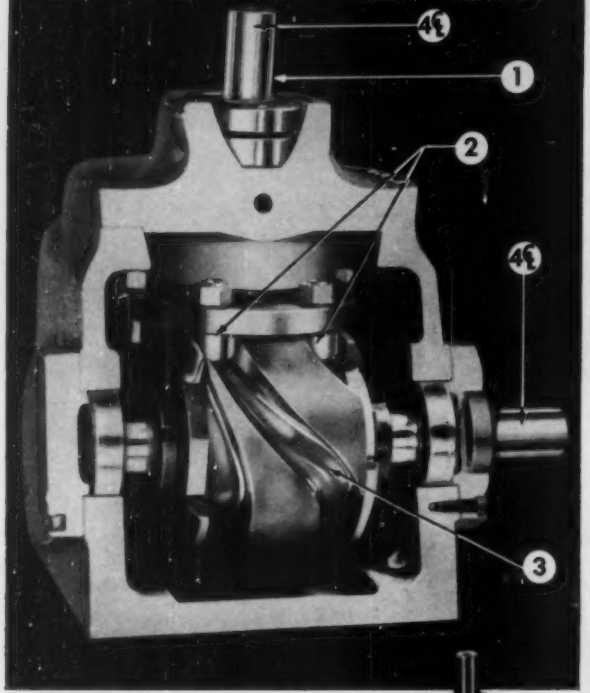

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Miniature flasher . . .

reportedly switches 150 w under severe environmental conditions. Static position device is fully transistor-equipped and potted; has automatic fail-safe; is explosion- and moisture-proof and resistant to gasoline and jet engine and hydraulic fuels. Can be used as a timing circuit with on-off ratio or on-off time to specification. Measures 3 x 3¾ x 2½ in. **Joseph Pollak Corp**, 81 Freeport St, Boston 22.

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Thermoelectric experimental kit . . .

contains typical cooling modules made of thermoelectric material and all necessary hardware to conduct basic experiments in thermoelectric cooling and power generation. Thirty-eight page instruction book and laboratory manual is included. Delivery in 10 days. **General Thermoelectric Corp**, Princeton, NJ.

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Velocity-type vibration probe . . .

has a moving weight of 0.1 gm and an output of 6 mv/in./sec with a 40-ohm coil, free to travel in excess of $\frac{5}{16}$-in. double amplitude. Output is fed directly to a high-gain scope. Has been used at frequencies from five to several thousand cycles per sec. Calibrated "finger" provides amplitude and frequency measurements in hard-to-get-to spots. **Dynamic Devices**, Dayton, Ohio.

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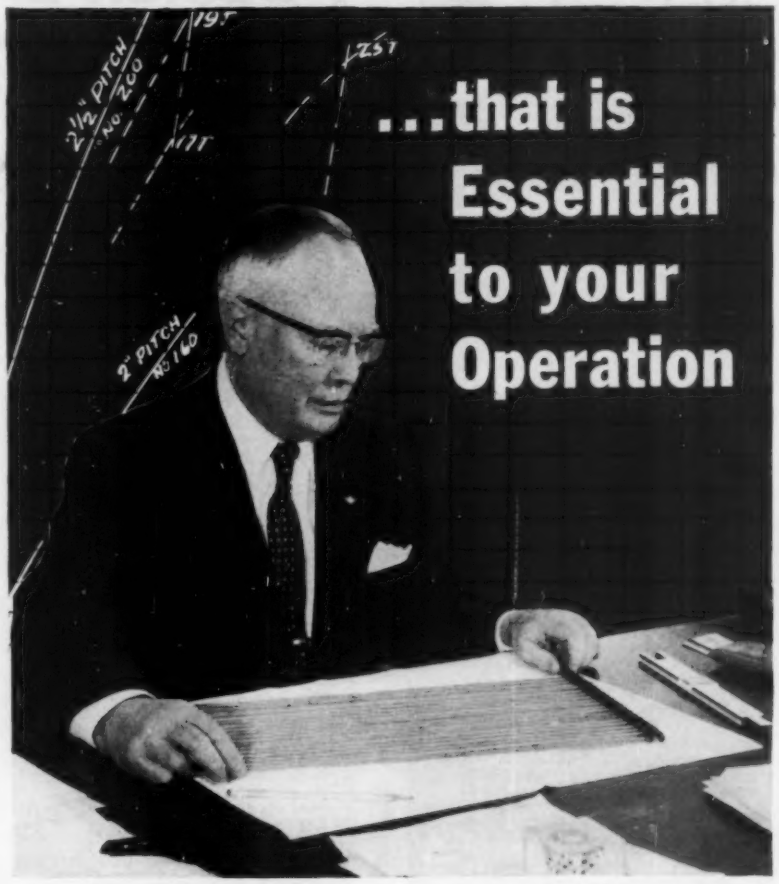

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DESIGN LITERATURE

The Scientist in American Industry

SIMON MARCSON. Harper & Bros, NYC, in cooperation with Industrial Relations Section, Princeton Univ. 5½ x 8½, 158 pp. $3.50.

This book reminds us of the special report, "Designtown," published last December in PRODUCT ENGINEERING. In that article, a study in depth of America's design engineer, the name of the industrial city surveyed was not given. Similarly, Mr Marcson's report on America's research scientists does not name the guinea pig. For convenience, he calls it "Pacific Electronics Co, a multi-plant company with a number of product-manufacturing divisions." We are told it has a large centralized laboratory that devotes two-thirds of its activity to developing findings for marketable products and is "typical of the larger, more progressive laboratories." The lab's 449 employes include 273 who are "professional," 26 supervisors, 134 technicians.

And as in "Designtown," written by an economist, there are problems at this lab described by Marcson, a sociologist. He found them in 12 months, off and on between Feb '58 and Feb '60, of investigating and talking with the scientists about such subjects as empire-building, status, salaries, gratifications, dissatisfactions.

Throughout runs this theme of communications trouble: The scientist-managers of industrial-research laboratories must "face in two directions; they must understand and speak two languages." They must, says Marcson, accent the business goals of the corporation; they must also show an understanding of, and respect for, the scientists' professional goals.

Because the "PEC" lab work is mostly applied research, there is also the theme of "sure results." One interviewee explained that difficult research is avoided: "You seek out those things which are simplest to do." Another said the lab does some basic research but "if there is no government contract or no gadget involved, management is not very enthusiastic."

Therefore big problems are discussed by this little book. Succeeding reports from Princeton will cover a government laboratory that concentrates on basic research, and a university that stresses both teaching and fundamental research. —WG

Machining Characteristics of High-strength Thermal-resistant Materials, Vol. 4

Wright Aeronautical Div, Curtiss-Wright Corp, Wood-Ridge, NJ. (AMC Technical Report 60-7-532) 7 x 10¼, 180 pp. $4.60.

The high-strength, high-temperature materials fulfill mechanical requirements that cannot be met by more easily worked metals. But making parts from these superalloys also must contend with poor machinability—slow machining speeds and high tool wear. For those who must machine these alloys and worry about productivity too, this book gives recommended tool materials and practical surface-cutting speeds and feeds.

Trigonometry—Refresher for Technical Men

A A KLAF, Dover Publications Inc, 180 Varick St, New York 14. 5½ x 8, 629 pp, paperbound. $2.

Solutions to specific problems in trigonometry are sometimes time-consuming when proper formulas and procedures are hard to pinpoint. This book simplifies such problems by a systematic arrangement of 913 spe-

continued on page 76

"Sure it's there. Look under the football pool, behind the thermos bottle, next to the coffee cups."

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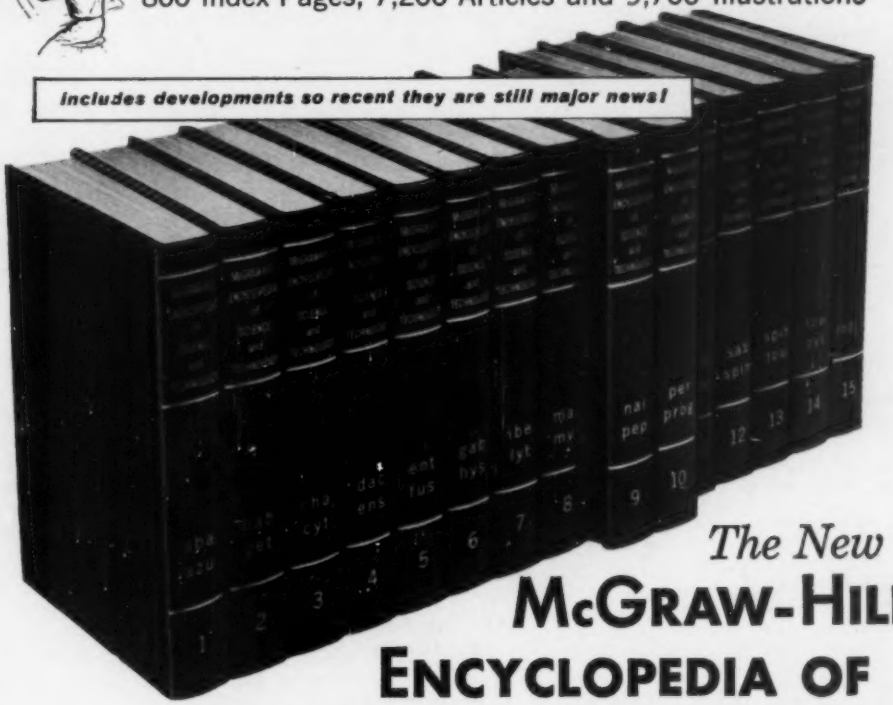

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Other Books of Interest

Creep and Plastic Deformation on Cylindrical Shells

PB 161706. A M Freudenthal, M P Bieniek. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8¼ x 11, 16 pp. 75¢.

On the Utilization of the Concept of Boundary Impedance in Vibrations of Bars

PB 161740. F J Wilmers, R F Lambert. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8¼ x 11, 39 pp. $1.25.

Organization Techniques of Industrial Enterprises

L Pehuet. Eyrolles, 61, boulevard Saint-Germain, Paris 5, France. 6½ x 9¾, 852 pp. Approx $18.55.

A collection of papers—in French—by prominent French management specialists.

ABSTRACTS FROM THE LITERATURE

Water-level Indicators for Boilers

Gage glasses show a lower water level than there actually is inside a high-temperature boiler. Denser water in the gage glass than in the steam drum causes this. The author discusses remote indicators and compensators which will give correct readings.

"Methods of Obtaining Accurate Boiler Water Level Indication," by J. W. Williams, Yarnall-Waring Co. American Society of Mechanical Engineers paper 60-WA-74, 29 W 39th St, New York 18.

Pneumatic Jet-pipe Valves

A potentially useful pneumatic pilot valve, where high performance, simplicity, reliability, and low cost are important, is the jet-pipe valve. Although the jet-pipe valve has been in use for many years, relatively little in the way of basic design information has been made available to the pneumatic-systems designer. This paper summarizes some of the results of a series of carefully planned tests with a jet-pipe valve operating with compressed air.

"Basic Characteristics of a Pneumatic Jet-Pipe Valve," K. N. Reid Jr, MIT, Cambridge, Mass. Paper No 38.3 published in NEREM Record, Nov '60, Institute of Radio Engineers, (Boston section), Boston.

Damping Aircraft Vibrations

Powerful engines in modern aircraft cause dangerous resonant vibrations. This paper discusses damping these vibrations with viscoelastic (rubbery) materials inside beams and in strips on top of them. Other ways of getting rid of vibrations or lessening their effects are also explained in Part I. Part II gives the results of tests on designing Part I.

"Damping Structural Resonances Using Viscoelastic Shear-damping Mechanisms," by J. E. Ruzicka, Barry Controls. American Society of Mechanical Engineers paper 60-WA-73 (Part I) and 60-WA-72 (Part II) 29 W 39th St, New York 18.

Plating Aluminum Diecastings

There exist certain fundamental principles that must be adhered to if a successful product is to be made. These are treated in turn.

"Plating and Anodizing of Aluminum Die-Castings," by Robert Harder, President, Lukens Aluminum Co, SDCE Paper No 11 presented at 1st SDCE Congress, Nov '60, Society of Die Casting Engineers Inc, 19382 James Couzins Highway, Detroit 35.

Effects of Heat on Man

The authors explain a system for rating discomfort in hot places. It is a calculated index for predicting human risk and need for correction and judging how well the corrections have worked.

"Problems in Rating Severity of Exposures to Heat," by H. S. Belding and T. F. Hatch, University of Pittsburgh. American Society of Mechanical Engineers paper 60-WA-232, 29 W 39th St, New York 18.

"Two weeks of work on this idea and he blows it up with one word . . . 'phooey' . . ."

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 79.

TORSION-RESILIENT COUPLINGS—Revised bulletin 4100, 24 pp. Tables outline selection data for standard model, including service factors, equivalent hp, K values and basic ratings. Dimensions and some selection information are given for other types: spacer, split cover, single cover, high-speed, double-piloted, brake-wheel and controlled-torque models. Falk Corp, PO Box 492, Milwaukee 1.

Circle 350 on Reader Service Card

METAL-CASED SWITCHES—Catalog 30-1, 16 pp. Contains force and movement specifications, electrical ratings, dimensional drawings and photographs of limit, safety, immersion-proof and sealed switches. Includes data on how to choose best suited switch and how to apply limit switches. Unimax Switch Div, W L Maxson Corp, Ives Rd, Wallingford, Conn.

Circle 351 on Reader Service Card

FIBERGLASS FABRICS—Booklet, approx 38 pp. Recommends specific constructions of fiberglass fabrics, woven rovings and tape for electrical reinforced plastic and coating industries and lists all fabrics by weight, thickness and price. Sketches show weave patterns. J P Stevens & Co Inc, Industrial Glass Fabrics Dept, Broadway & 41st St., New York 36.

Circle 352 on Reader Service Card

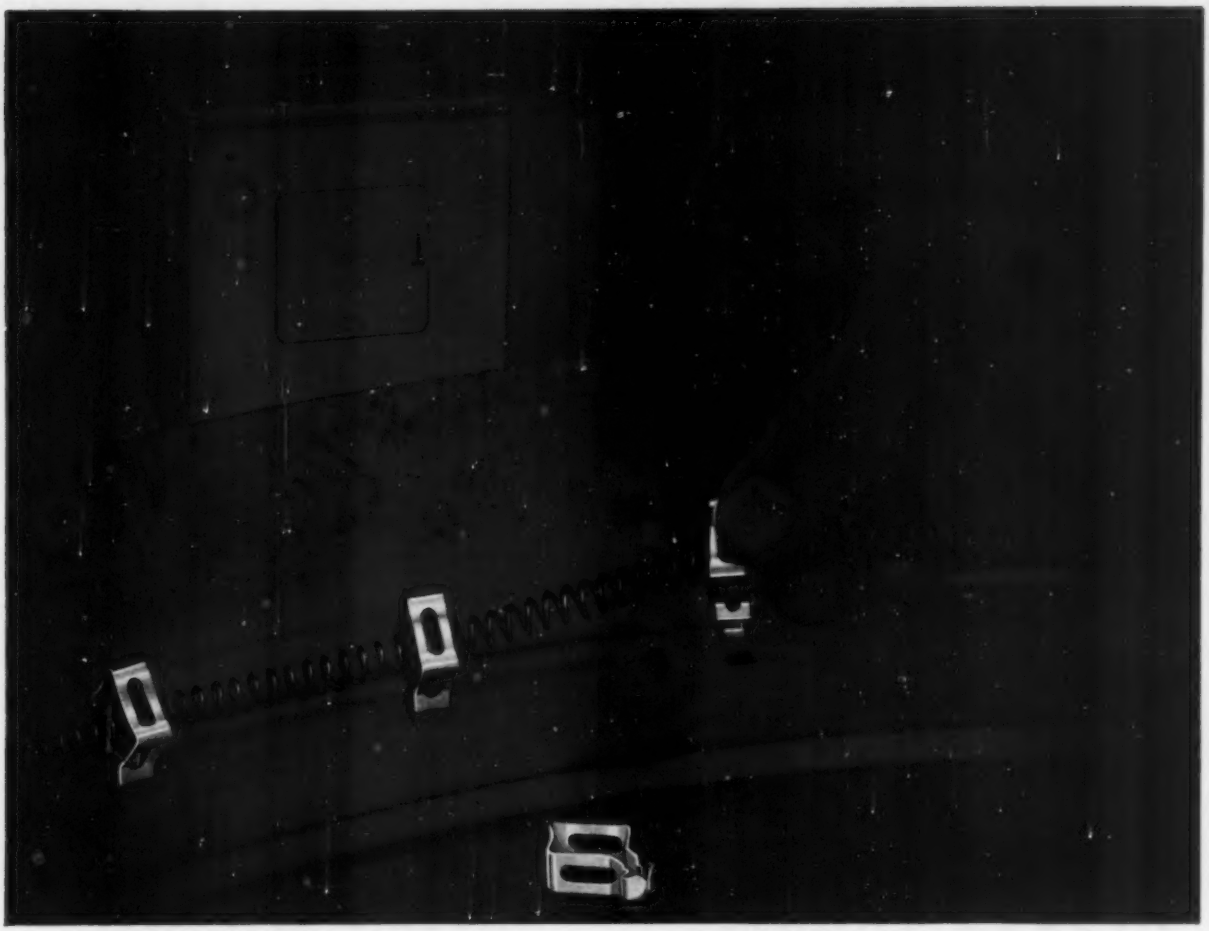
NUT AND BOLT STRENGTH—Booklet, vol 26, no 1, 14 pp. Explains what's meant by shear, tensile and yield strength, elongation, cold working, stress corrosion, creep, temperature control, metal fatigue, etc. and how these properties are achieved. Table outlines chemical and mechanical properties of high-strength alloys. H M Harper Co, 8200 Lehigh Ave, Morton Grove, Ill.

Circle 353 on Reader Service Card

CLAMPING CYLINDERS — Bulletin 91036, 4 pp. Supplies specifications, dimensions and outline drawings of single- or double-acting units and valve-cylinder combinations. Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.

Circle 354 on Reader Service Card

continued on page 79



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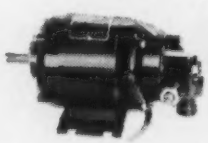

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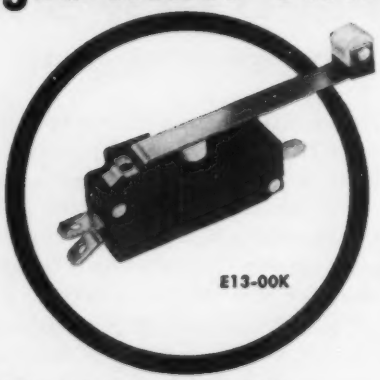

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ABS PLASTIC—Brochure, 70750, 20 pp. Traces physical and chemical data of Type MH plastic developed for injection molding. Curves show flexural modulus and strength vs temperature; heat deflection temperature vs load; tensile creep; and apparent modulus. Naugatuck Chemical Div, US Rubber Co, Naugatuck, Conn.

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MOTORS FOR LIMITED SPACE—Bulletin GEA-6927B, 8 pp. Describes and illustrates line of 1 through 5-hp units in dripproof and enclosed construction. Interchangeable end shield dimensions are tabulated, while large cutaway drawing shows design features. General Electric Co, Schenectady 5.

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LABORATORY SEPARATORS—Catalog, approx 94 pp. Covers specifications, operating principles and construction of electro- and permanent magnetic equipment, including: tube tester, crossbelt, induced roll, wet drum, cobber pulley, and electrostatic separators. Dings Magnetic Separator Co, 4740 W Electric Ave, Milwaukee 46.

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FRACTIONAL-HP MOTORS—Bulletin B-2514, 8 pp. Describes design and performance characteristics of 1/20 through ¾-hp units. Includes dimensional and cutaway drawings. Reliance Electric & Engineering Co, 24701 Euclid Ave, Cleveland 17.

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VIBRATORY FINISHERS—Booklet, 12 pp. Discusses advantages of vibratory process over conventional barrel finishing and compares the two in work load, time cycle and rate of pieces completed per hour. Vibraslide Inc, 95 Prospect Ave, Binghamton, NY.

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MACHINABLE CARBIDES – Manual, 12 pp. Offers physical properties and fabricating and processing instructions for Grade C, steel-bonded carbides. Also discusses typical tooling problems solved with materials, and illustrates applications. Sintercast Div, Chromalloy Corp, 171 Western Hghwy, West Nyack, NY.

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FRACTIONAL-HP AC MOTORS—Bulletin, 4 pp. Outlines speeds, power requirements and dimensions of 2-, 4- and 6-pole shaded-pole units and a 6-pole permanent split capacitor series—all in the 1/150 through ¼-hp range. Leece-Nevile Co, 989 Athens St, Gainesville, Ga.

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HARDENED IRON, STEEL ROLLS—Bulletin B-160, 24 pp. Describes heat-transfer rolls; carburizing process; suggestions for design using carburizing process; heat-treating facilities; dual-metal-chilled iron rolls and representative products. Badall Co Inc, Dept F, Hammond, Ind.

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PRESSURE TRANSDUCER TERMS—Folder, 4 pp. Defines terms used to describe transducer and sensing element types; pressure ranges; strain-gage characteristics; performance parameters and compensation and shunt calibration. Standard Controls, 1130 Poplar Pl, Seattle 44.

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ELECTRIC TACHOMETERS – Bulletin, 4 pp. Describes and illustrates nine models in photos and dimensional drawings. Generators for use with tachometer indicators also are pictured and discussed. Electro Mechano Co, 241 E Erie St, Milwaukee.

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DRAFTING TEMPLETS—Catalog 65, 20 pp. Carries photographs and size data on 115 templets, including electrical, mechanical engineering, general purpose, and lettering types. Rapidesign Inc, PO Box 429, Burbank, Calif.

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METAL O-RINGS—Sliderule, 4 x 9¼. Covers plain, plated and coated ring diameters from ¼ to 50 in. Includes data for calculating correct installation dimensions for nonstandard sizes. Advanced Products Co, 59 Broadway, New Haven, Conn.

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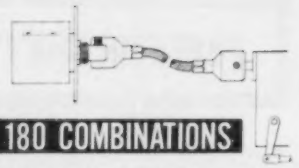

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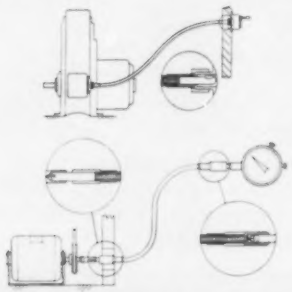

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352—Fiberglass Fabrics, 38 pp, J P Stevens & Co Inc.
357—Laboratory Separators, 94 pp, Dings Magnetic Separator Co.
364—Pressure Transducer Terms, 4 pp, Standard Controls
365—Electric Tachometers, 4 pp, Electro Mechano Co.

HYDRAULIC, PNEUMATIC EQUIPMENT

354—Clamping Cylinders, 4 pp, Airmatic Valve Inc.
364—Pressure Transducer Terms, 4 pp, Standard Controls

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Name ..... Title .....

Street .....

City ..... Zone ..... State .....

Company ..... Major Product Manufactured .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P66	P67	P68	P69	P70	P71	P72	P73	P74	P75	P76	P77
P78	P79	580	581	582	583	584	585	586	587	588	589

*MULTIPLE Key No.	PRODUCT ADS Specific Product

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After reading the advertisements classified above . . . MORE DETAILED INFORMATION about these products can be obtained by using the attached READER SERVICE CARD. **84**

Issue of February 27, 1961
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Card expires April 27, 1961

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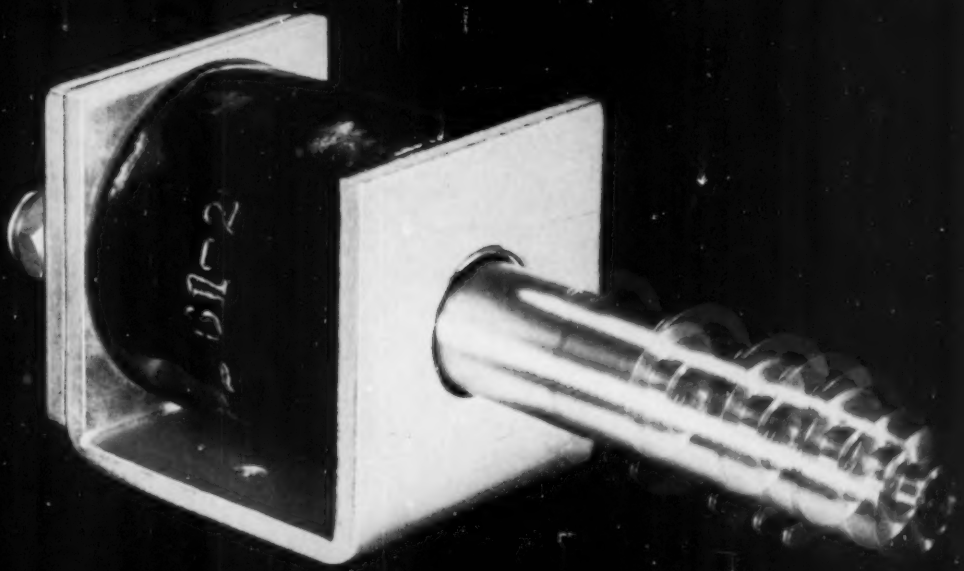
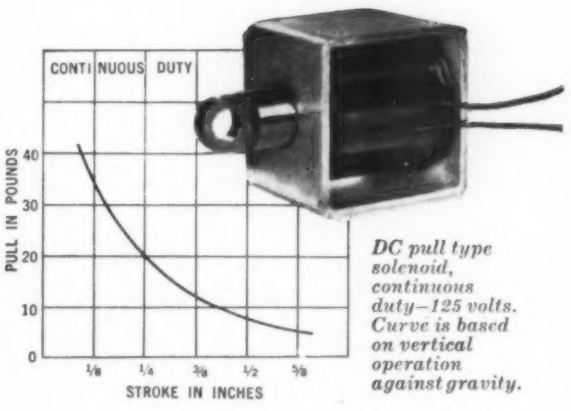


new ASCO solenoid has virtually unlimited life . . . outstanding economy

In this case "unlimited life" is a simple statement of fact. ASCO's new solenoid is manufactured to such precise tolerances (±0.0005") that wear is virtually non-existent. In ordinary solenoids, the plunger rides loosely in the sleeve—inviting wear. But in ASCO's long-life solenoid, the plunger is guided by a machine tool bearing that assures accurate stroking and reduces friction to an absolute minimum.

Because this solenoid was engineered with quality as the prime consideration, its initial cost is higher. However, it is in fact *the most economical solenoid you can buy* because, once installed, it can practically be forgotten. This solenoid will still be functioning 100 million operations later—long after standard types have been replaced—and replaced—and replaced. For additional information, contact your ASCO engineer or write for Catalog 57-S5.



DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

ASCO Electromagnetic Control

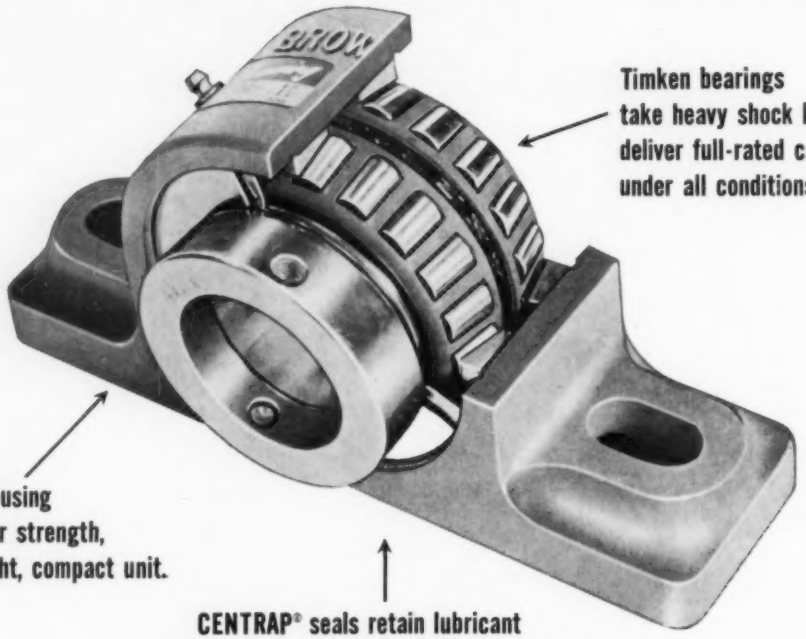
Automatic Switch Co. 54-G HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO

CIRCLE 202 ON READER SERVICE CARD

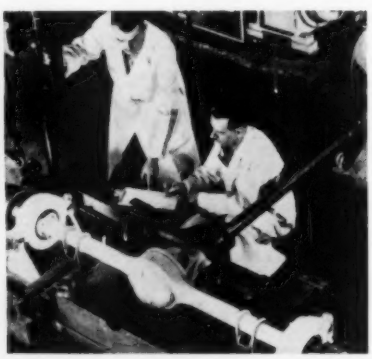
Browning malleable housings team up with Timken® bearings for greater capacity and strength



To be sure their PB900 pillow block has maximum ability to take heavy loads, Browning Manufacturing Company, Maysville, Kentucky, uses a malleable housing and Timken® tapered roller bearings. The malleable housing permits a stronger yet lighter, more compact unit. The Timken bearings provide higher load-carrying capacity and longer life in minimum space—more than any other type of bearing.

It's the tapered design of Timken bearings that enables them to take *both* radial and thrust loads. Full-line contact between rollers and races and precision manufacture give Timken bearings *extra* load-carrying capacity. And they're made from the finest bearing-quality alloy steel available to withstand shock.

OUR ON-THE-SPOT ENGINEERING SERVICE saves customers time and trouble. Our graduate engineer salesmen help you select the most economical bearing for your job.



TESTING FACILITIES in our modern laboratories help us solve customer bearing problems—develop new bearings just as we did for Browning Manufacturing Company.

Industry rolls on

TIMKEN®

tapered roller bearings

The Timken Roller Bearing Company, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ontario.

CIRCLE 203 ON READER SERVICE CARD